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An empirical evaluation of ICT tools designed to support water environmental awareness

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Abstract

The United Nations launched their 'Decade for Sustainable Development', which directly relates to Education for Sustainable Development, a new environmental management system for schools. The formal education process provides a key testing ground for the development of new Information and Communication Technology (ICT) tools designed to raise environmental awareness. Several types of purpose designed ICT tool are available, but there is a distinct lack of empirical research into their design and effectiveness. Strategic objectives performance takes the central role in the work reported here. A number of strategic objectives of the use of ICT tools were identified; learning, education, trust, motivation, commitment, inclusion, justice and openness. A number of pre-existing software platforms, each specifically designed to provide environmental education and to raise awareness specifically focussing on issues surrounding water were selected and formally evaluated under controlled conditions with small groups of evaluators. The respondents involved in this investigation included the developers of the tools themselves, school and postgraduate students (representing users) and experts from academia and industry. The developers of the tools were asked which strategic objectives they considered when they designed their respective tools and the degree to which their tools promoted the strategic objectives was tested in evaluation sessions involving the users. The results from the evaluation sessions involving the users and the experts revealed that strategic objectives such as learning, education, trust and openness were promoted by the tools to some degree, whilst objectives such as justice, motivation and inclusion were promoted to a lesser degree. Whilst it is possible that the tools evaluated simply do not promote the objectives listed, the evaluation methodology adopted in this investigation may go some way to explaining why only certain strategic objectives were found to be promoted. A discussion into the possible methods by which the presence of these strategic objectives could be determined is presented in the concluding chapters of the thesis.

Keywords: Environmental awareness; ICT tools; Design; Evaluation

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Glossary

Empirical evaluation:	Involves the use of questionnaires, interviews and user testing
Heuristics:	A method or set of rules for solving problems other than algorithms, helping to learn, guiding in discovery or investigation (Collins, 1994)
ICT Tools:	Information and Communication Technology tools. A computer tool that enhances learning and communication. These tools can have many uses but in this thesis are tools which can support environmental awareness
Public participation:	In this thesis public participation is considered a special case in terms of wider stakeholder engagement, which broadens the constituency of influence

1 Introduction

1.1 Background

Environmental education has become an increasingly important aspect of school curricula in recent years. There has also been an increase in the promotion of sustainable living and environmental awareness by decision makers to members of the public. People's understanding of their place in the environment is an important consideration in this thesis. It has been suggested that the way in which individuals visualize environmental problems varies according to where the individual pictures his place in the environment. For example, Arne Naess, the Norwegian philosopher, hypothesised that individuals view environmental problems in either an isolated way, or holistically and concluded that the latter form provides an opportunity for mankind and the environment to exist in symbiosis (Higgins, 1998). If such an ambition is to be pursued, the various ways in which environmental decisions are made must be identified and understood. The concepts of technocentrism, ecocentrism and sustaincentrism have all been proposed as practical methods of environmental management, sustaincentrism attempting to combine the other two concepts (Higgins, 1998). Technocentrism and anthropocentrism are two environmental attitudes that make up the interventionalist interpretation (Toronto University, 2001). This interpretation takes the view that humans and nature are separate entities and the environment is managed for human benefit. Ecocentrism adopts a different stance, placing nature as the central component of importance. This concept places mankind in its natural setting, with the belief that humans and nature exist in a harmonious state (Toronto University, 2001). This view also maintains that humans have a responsibility to manage and maintain the environment.

Huesemann (2001) observed the technocratic mindset that society has traditionally adopted when he questioned the dependency of society on existing science and technology to remediate pollution problems. Technological innovation has been found to yield environmental deterioration yet technology can be seen as both the main cause

of, and solution to, many modern environmental problems. Huesemann proposed three fundamental assumptions that society places on technology:

1. Science can provide us with enough detailed knowledge about nature to solve and prevent environmental problems.
2. Remediation techniques can successfully remove pollution without causing other unforeseen negative environmental impacts elsewhere.
3. It is possible to prevent pollution in the future and develop 'clean' industrial processes that have no environmental impacts.

In order to move away from society's misplaced assumptions about the capabilities of science and technology, awareness with regards to environmental issues needs to be raised. Relying on technology to solve environmental problems is not a long term solution and rather, it is of greater benefit to the environment if society attempts to reduce its impact on the environment by leading environmentally responsible lifestyles. To do this, the awareness of the problems of relying on science and technology, the environmental issues that present themselves and the ways in which society as a whole can become more environmentally responsible needs to be raised.

Various conferences and new pieces of legislation such as Agenda 21 (UNCED, 1992) have outlined the need for sustainable development and the importance of providing citizens with the knowledge necessary to enable them to adopt sustainable lifestyles (Newhouse, 1990, Pooley and Connor 2000). In recent times, the benefits of providing environmental education to the younger members of society have become apparent, the assumption being that if individuals are encouraged at a young age to become environmentally aware, they may be encouraged to be environmentally responsible in the future. (Stoney, 1995; Legault and Pelletier, 2000, Wilson, 2000) The phrase 'environmentally responsible adults' is taken to mean that becoming environmentally aware from a young age would engender feelings of responsibility as adults, therefore encouraging individuals to implement sound environmental practises in their own homes. If becoming environmentally aware leads people to become more environmentally responsible, (and encourages sustainable lifestyles) then they could be

discouraged to the benefit of ecocentrism. By working to balance these concepts sustainable development could be enhanced.

This is not as easy as it appears however. It is not simply a case of asking an individual to assess their impact on the environment and bring about positive change. In today's 'throw away' society, where life is fast paced and convenience is all important, individuals have little time to consider the environment, let alone to modify their lifestyles. Even when individuals are keen to become more sustainable, it takes time (and more often than not money) to realise a low environmental impact lifestyle. However, if individuals are encouraged to take responsibility for the environment (preferably at a young age), then there will be little need for them to alter their habits. Making sustainable practices in the home second nature can be achieved through education.

Although the environment has been covered in the curriculum to some extent through the teaching of geography and science in formal education, legislation has led to the inclusion of new areas in the national curriculum. These are Education for Sustainable Development (ESD) and Citizenship. Both are beneficial to the teaching of environmental education and awareness raising. The United Nations Decade for Sustainable Development aims to implement ESD into a number of learning institutions (DfES, 2005). ESD is not a national curriculum subject in itself, rather it is an environmental management system which involves school children and directly tackles the issues surrounding sustainability. It is cross curricular which means that it links to other subjects in the national curriculum. Citizenship has been a compulsory national curriculum subject since August 2002 and aids pupils in becoming socially responsible citizens, as well as teaching them the importance of inclusion and democracy in society. There are a number of different initiatives available to teachers to aid them in satisfying the objectives of both ESD and citizenship, some examples being Eco-Schools (Eco-Schools, 2005), Bird Friendly Schools (RSPB, 2004) and Growing Schools (DfES, 2004) to name a few.

Other resources are ICT based and these include K-World (Environment Agency, 2002) and the Water Aid Game (Water Aid, 2000). There are a number of benefits to using ICT tools to promote environmental awareness, including the varied ways in which information can be presented in the tools. Some environmental awareness focussed ICT tools have been developed so that they build on individuals' existing knowledge, whilst others accommodate different learning styles (Wild and Quinn, 1998). Some ICT tools are able to bring together individuals, and allow the flow of information from one person to another.

1.2 Policy Context

The first international recognition of the impact that society was having on the environment was revealed in the 1980's, when the Brundtland Commission published a report called 'Our Common Future'. This identified the negative impact that anthropogenic activity was having on the environment. Linking this to education, the United Nations Conference on Environment and Development or the Rio 'Earth Summit' (UNCED, 1992) revealed the real need to consider environmental education on a number of levels. Specifically, Agenda 21 laid out principles which consider not only the role of individuals in sustainable development, but also the need and importance of public participation.

The Aarhus convention in 1998 (UNCED, 1998) continued with the development of guidelines with regard to environmental awareness and public inclusion, and the significance of citizen participation in decision making was emphasized by the conference delegates. The Aarhus convention resulted in a set of directives, which ensured that citizens would have access to environmental education (Directive 2003/4/EC), be able to participate in decision making (CEC, Directive 2003/35/EC) and have access to justice in environmental matters (CEC, Directive 2003/4/EC and Directive 2003/35/EC).

Many conferences have taken place which focus specifically on environmental awareness, beginning with the United Nations Conference on the Human Environment in 1972 (Hawthorne and Alabaster, 1999). Other conferences followed including the

UNESCO environmental education conference in 1977 (Mesarovic and Pestel, 1974), the International Union for the Conservation of Nature and Natural Resources, the United Nationals Environmental Program and the World Conservation Strategy (Hawthorne and Alabaster, 1999). Relating to environmental education, Article 13 of the United Nations convention of biological diversity considered public education and awareness.

Finally, the United Nations recently launched their 'Decade for Sustainable Development', which directly relates to Education for Sustainable Development, the environmental management system for schools. The legislation supporting this thesis is discussed in more detail in Chapter 2, and the next section outlines the need for investigations to be carried out on the design and evaluation of ICT tools to support environmental education and awareness.

1.3 Scope of the thesis

The study reported in this thesis focuses on the evaluation of ICT tools which have been designed to support environmental awareness. The central aim of the thesis is to determine the extent to which ICT tools designed to support the public understanding of environmental issues, specially related to water, achieve their strategic objectives. This was carried out by conducting a targeted literature review. The inclusion of strategic objectives is of particular interest in this thesis. The strategic objectives required for consideration to enable successful ICT tool design and enable environmental education were first isolated and then evaluation work was executed to determine whether existing ICT tools promoted such objectives. This involved the design of an appropriate research methodology to determine strategic objective promotion by ICT tools. Another aim of the work was to suggest which changes need to be made to pre existing tools in order to design effective tools for environmental education. Finally, this research revealed opportunities for possible future investigations in this area.

This investigation concentrates on the wider issues of the design and evaluation of ICT tools to support environmental awareness. However, this thesis does not concentrate on

the usability aspects of specific tools, although it does refer to past evaluation investigations which have focused on the elements of the human-computer interface.

The final section in this chapter will provide an outline for the thesis as well as presenting the publications written during the investigation work.

1.4 Outline of thesis and publications

An in-depth review of the literature (Chapter 2) is the first step in the thesis development. The literature survey is separated into eight sections. The first and second sections provide an introduction to both sustainable development and environmental awareness respectively. The other sections concentrate more specifically on ICT tools, their links with environmental awareness promotion and sustainable development and their structure. From this, the focus of the thesis which is the evaluation of ICT tools in terms of the promotion of certain strategic objectives is outlined. Finally, an overview of the options for the evaluation of ICT tools in terms of strategic objectives will is presented, followed by the options for the evaluation of ICT tools in general.

The methodologies discussed in Chapter 3 centre around the development of evaluation sessions within which the promotion of certain strategic objectives by existing ICT tools for water education can be tested. These strategic objectives were explored in a paper submitted to the IWA, WATERMATEX conference (Beijing, 2004) which was accepted as a poster presentation (Swinford, A., McIntosh, B.S., Jeffrey, P., 2004. 'ICT tools to support public participation; the importance of strategic functions').

The findings of these evaluation activities (reported in Chapter 4) were submitted in written format to The International Environmental Modelling and Software Society 2004 conference (iEMSs). This paper was accepted as an oral presentation (Swinford, A., McIntosh, B., Jeffrey, P., 2004. Supporting the strategic objectives of participative water resources management; an evaluation of the performance of four ICT tools. *In: The international environmental modelling and software society conference (iEMSs)*, June 2004, ZUK, Zentrum fur Unweltkommunikation, Osnabruck, Germany (CD-

ROM).) Subsequent to the iEMSs conference, the paper was combined with another paper focussing on the same area of research, for publication in the journal 'Environmental Modelling and Software' (Maurel, P., Cernesson, F., Ferrand, N., Craps, M., Valkering, P., Swinford, A., McIntosh, B.S., Jeffrey, P., (In Press) Concepts and methods for analysing the role of ICT tools in Social Learning processes for River Basin Management. *Environmental Modelling and Software*).

Chapter 5 discusses the findings of the investigation and conclusions are listed in Chapter 6. Recommendations for future work are also suggested in this final chapter.

1.4.1 Other Publications

SWAP (Science for Water Policy) conference (Swinford, A., McIntosh, B., & Jeffrey, P., 2002. The design of Information & Communication Technologies to support participative processes under the Water Framework Directive: A model for design and evaluation. *In: Proceedings of Science for Water Policy (SWAP), September 2002 University of East Anglia, Norwich*, 341- 359.)

MULINO conference (Swinford, A., Jeffrey, P.J., 2002. Designing ICT tools to support participative catchment management processes. *In: Policies and tools for the sustainable water management in the UK (MULINO), November 2002 Fondazione Eni Enrico Mattei, Venice, Italy*, (CD-ROM)).

2 Literature Review

In this chapter, a review of the relevant literature on issues of both environmental awareness and responsibility is presented. This is made up of six sections. The first provides an introduction to sustainable development, whilst the second section discusses the various aspects of environmental awareness. The third section discusses the role of ICT tools in various contexts and then goes on to consider links with environmental awareness. The structure of ICT tools is outlined in Section 2.4, and from this, the focus of the thesis which is the evaluation of ICT tools in terms of the promotion of certain strategic objectives is outlined in Section 2.5. Finally, an overview of how researchers have previously addressed the evaluation of ICT tools in terms of strategic objectives will be presented, followed by a more general discussion of how ICT tools in general have been assessed. In this thesis, ICT tool is defined as 'A computer tool that enhances learning and communication'.

2.1 Sustainable Development

In the 1980's the term sustainable development was first used when it was clear that anthropogenic activity was having such a large effect on the environment that it was feared that the earth's natural systems would be unable to support future generations. The overall message was that the natural environmental thresholds were being approached, if not exceeded. Sustainable development was the key theme of the 'Our Common Future' document written in 1987 by the World Commission on Environment and Development (Brundtland, 1987).

'Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.' (Brundtland Commission, 1987)

On the DfES (2005) website, where it refers to the new theme of Education for Sustainable Development (ESD) the following definition for Sustainable Development is used.

Sustainable *means that something is viable and can be continued in the long term in ways that do not harm people but benefit them equally. This can apply to anything from decisions about the school playground to issues relating to the national economy and global environment*

Development *refers to the way in which the interaction between the environment, the economy and society progresses and changes. Development happens everywhere and involves everyone.*

Sustainable Development *is about ensuring a better quality of life for everyone now and for generations to come'* (DfES, 2005).

It has also become clear to some individuals that sustainable development could be a process of change rather than an end point or a single globally relevant objective (DfES, 2005). It has become widely recognised that sustainable development differs according to different local contexts, interests and needs (DfES, 2005). The relevance of the concept of sustainable development is discussed later in this section.

During recent years the focus has moved towards citizen involvement in debates on environmental sustainability, this being a major theme during the United Nations Conference on Environment and Development, also known as the Rio 'Earth Summit' in 1992 (UNCED, 1992). Agenda 21 was the major outcome from UNCED and it recognised the importance of education on a number of levels, including training, formal education and public awareness. Therefore it was established that, to enable public involvement in decision making, education was crucial. Further to this, of the principles laid out in Agenda 21, Principles 1 and 10 are of significant to this thesis. Principle 1 considers the central role of human beings in sustainable development, whilst Principle 10 states the need for, and importance of, citizen participation, to resolve environmental issues, as well as speaking of encouraging public awareness and participation. It was concluded by Hawthorne and Alabaster (1999) that Agenda 21 recognises:

..that to deal with the phenomenon of global environmental change, it is necessary to devise the right strategies to foster a sense of responsibility and involve people in the search for solutions.

Agenda 21 therefore focussed on devising strategies to engender environmental responsibility in individuals, by raising environmental awareness and also by involving individuals in the search for solutions. It is at this point in environmental legislative history that two paths emerge. Agenda 21 recognised the need for environmental awareness and education, but also began to identify the benefits of citizen involvement and stakeholder engagement processes. In this thesis, the former theme will provide the main focus. However it is important to consider other legislation which makes reference to the role played by environmental awareness. An example is the Aarhus Convention, the main objective of which was to reach a general consensus regarding public participation in environmental issues. Each party attending the convention agreed to guarantee citizen inclusion in the decision making process, ensure public access to information and make certain that justice was achieved in environmental matters (UNCED, 1998). The EU incorporated the findings of the Aarhus convention into a set of directives, those pertaining to both environmental awareness and stakeholder engagement including: 'Access to information' (Directive 2003/4/EC), 'Public participation' (CEC, Directive 2003/35/EC) and 'Access to justice in environmental matters' (CEC, Directive 2003/4/EC and Directive 2003/35/EC).

Since the Rio 'Earth Summit' and the formulation of Agenda 21, many international conferences have looked at education and sustainability and the outcomes of each have drawn similar conclusions; that it is necessary to educate citizens so that they have the knowledge to adopt a more sustainable lifestyle. As discussed by Hawthorne and Alabaster in their 1999 paper, environmental citizenship was stated to be the ultimate outcome of ESD. They defined this as a process which entailed providing access to knowledge and changing people's attitudes, thereby influencing human behaviour. For the moment however, it is necessary to remember that education and changing attitudes are important factors for engendering environmental responsibility.

2.2 Environmental Awareness

In 1997, Michael Bonnett in reflecting on past environmental issues, identified that environmental concern in some respects was at its most intense during the late 1960's and early 1970's and since that time, environmental awareness has only increased in both importance and recognition (Bonnett, 1997). This observation is reflected in the history of environmental legislation which seeks to raise awareness and encourage environmentally responsible behaviour, beginning in 1972 with the United Nations Conference on the Human Environment. The resounding outcome of this gathering was the agreement that:

'environmental education should be international, interdisciplinary, and ...encompassing all levels of education and directed towards the general public, in particular , the ordinary citizen – with a view to educating him [or her] as to the simple steps he [or she] might take –to manage and control his [or her] environment. (Cited in Hawthorne and Alabaster, 1999)

Over the next 20 years, many other international conferences took place, each one echoing the sentiment outlined above. These included the second report to the club of Rome as outlined by Mesarovic and Pestel (1974) as well as the UNESCO environmental education conference in 1977. During 1980, the International Union for the Conservation of Nature and Natural Resources, the United Nations Environmental program and World Wildlife Fund, took place, which considered a World Conservation Strategy. Later on in the 1980's the Brundtland Report was released, and a further World Conservation Strategy was considered in 1991 (Hawthorne and Alabaster, 1999).

In more recent times, the pertinent environmental education policies of relevance to this thesis include the United Nations convention on biological diversity, of which Article 13 is of importance as it considers public education and awareness (United Nations, 1993). The article focussed on providing information to the public, through the media

with regards to the conservation of biological diversity. It also recommends that these topics are included in educational programs.

The most recent advancement in legislative history relevant to environmental education is the United Nations 'Decade for Sustainable Development (United Nations, 2005), which begins in 2005 and focuses on the promotion of education for sustainable development (ESD).

The importance of introducing the concept of sustainable development through engendering a feeling of environmental responsibility and increasing environmental awareness in citizens at an early age have been recognised, and has led to the introduction of associated topics to the U.K. national curriculum. One such topic is 'Education for Sustainable Development' (ESD). Rather than be adopted as a single subject, like Maths or English for example, ESD spans the whole curriculum and management of a school.

'Education for sustainable development enables people to develop the knowledge, values and skills to participate in decisions about the way we do things individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future' (DfES, 2005).

The DfES describe ESD as being essentially cross curricular, with links to Geography, Science and Citizenship. However, it can also be linked to a range of other national curriculum subjects such as numeracy, literacy and art and can also aid in both developing and strengthening thinking and decision making skills. Although devising a definition for ESD appears on the surface to be fraught with difficulties, and the way in which individuals comprehend this definition would in reality be varied, many individuals working within the national curriculum have found that breaking ESD down into seven interrelated concepts helps. Proposed by the Government Panel for Sustainable Development Education (DfES, 2005), Table 2.1 presents these concepts.

Table 2.1 – The seven interrelated concepts of ESD (DfES, 2005)

Concept	Learning outcome
Interdependence	That pupils understand the links between their own lives and those of other individuals both on a local and global scale. They are also made aware that decisions made in one place will have direct or indirect impacts in other places.
Citizenship and Stewardship	That pupils realise that everyone has rights and have a responsibility to take part in decision making. It is also important that they understand that everyone should have a say in what happens in the future.
Needs and rights of future generations	That pupils learn to lead lives in such as way that they are considerate to others. Also realising that how we live now will have implications for future generations.
Diversity	That pupils understand the value of diversity and that diversity can mean culturally, socially, economically and biologically, and that we are impoverished without it.
Quality of Life	That pupils understand that the benefits of sustainability must be distributed in an equitable way
Sustainable change	That pupils understand that development in richer countries is limited and if this development is unmanaged and unsustainable this will increase both hardship and poverty and could contribute to the degradation of the environment, which will be a disadvantage to everyone.
Uncertainty and Precaution	That pupils realise that we are learning about the environment all the time and that some of our previous or current actions may have unforeseen circumstances. Therefore we should a cautious approach to the welfare of the planet.

Further to ESD, a relatively new national curriculum subject warrants consideration. 'Citizenship' has been defined by the 'Advisory Group on Education for Citizenship and the Teaching of Democracy in Schools' (DfES, 2005) as being made up of three interrelated components, which should be reiterated throughout citizenship lessons. These are shown in Table 2.2:

Table 2.2 – The interrelated components of citizenship (DfES, 2005)

Component	Learning outcomes
Social and moral responsibility	Pupils learn that self-confidence and socially and morally responsible behaviour both in and beyond the classroom, towards those in authority and towards each other.
Community involvement	Pupils learn the importance of becoming involved in a helpful way in neighbourhood and community life, including learning that both community involvement and service is important.
Political literacy	Pupils learn about democracy in terms of practices, institutions and problems and how that they can become effective in society.

As well as these key components, it is envisioned that through learning about citizenship pupils will also develop:

- *Skills of enquiry*
- *Communication*
- *Participation*
- *Responsible action through learning about and becoming informed and interested citizens.*

(DfES, 2005)

In order to ensure the effective teaching of citizenship and to guarantee that the skills listed above are developed, ways need to be devised where the concepts introduced in the classroom can be related to real life situations that take place outside the school, both at the local and global scale. A discussion of citizenship is relevant to this thesis because the key components of the citizenship curriculum are directly relevant to the components necessary for raising environmental awareness and encouraging environmentally responsible behaviour. For example, the adoption of more environmentally friendly lifestyles might involve exploring water conservation options, thereby developing existing enquiry skills. This interest in the environment and learning of ways to conserve the environment within the home, may then lead to action, and

participation could either be through adopting a more environmentally aware lifestyle or by volunteering to help with environmental projects or decision making. Finally, for this process to take place, from the individual becoming aware of environmental issues, to finding out about them and learning about how they can become environmentally responsible and making changes to their own lifestyles, clear communication of environmental issues is vital.

A contemporary example of how teachers can satisfy both the ESD and citizenship components of the national curriculum is through the involvement with the Eco-schools initiative which was created by the Foundation for Environmental Education (FEE) and is managed by ENCAMS (Eco-Schools, 2005). It is an international initiative currently operating in 27 countries, across, Europe, Africa and South America. Eco-Schools is a scheme which promotes environmental awareness in schools by linking it to other national curriculum subjects, including citizenship, ESD and personal, social and health education (PSHE). By participating in this programme, not only do schools satisfy a number of objectives on the curriculum, but can also achieve various awards, which raises the profile of the school.

Therefore from numerous environmental policies, through the national curriculum, namely ESD, to various initiatives such as Eco-schools and the formation of various foundations and councils, there has been a general increase in efforts to raise environmental awareness in younger individuals.

Other initiatives exist which can be used by schools to raise environmental awareness in pupils and to satisfy learning objectives in ESD and citizenship. Bird Friendly Schools is one such initiative run by the RSPB. An RSPB volunteer visits the school to work with the teacher to show them how they can teach the class about birds and wildlife at school (RSPB, 2004). The DfES developed the 'Growing Schools' initiative, which is designed to involve school pupils in activities related to their school's gardens and grounds. Teachers are able to use different aspects of their school grounds to create educational activities relevant to the curriculum, and the DfES aided teachers in doing so by providing an information pack with ideas that could involve the class. Examples of these activities vary from designing hanging bird feeders, to growing wildflowers and

making willow sculptures (DfES, 2004). Finally, The Countryside Agency developed information packs for both primary and secondary schools which provided information about the countryside code, as well as issuing help to teachers who are planning field trips. Suggestions for activities are also included, examples of activities being a litter count, species hunt and bird identification (The Countryside Agency, 2005).

This section has sought to demonstrate that the need to raise environmental awareness in younger individuals, so that they might grow up to become environmentally responsible individuals, has been recognised. The DfES identified this need by adding new concepts and subjects such as ESD and citizenship to the national curriculum. One example of the way in which teachers are helped to satisfy teaching criteria in these fields is the online, freely available initiative called Eco-Schools.

The following sections in the thesis consider the role of ICT tools for education in general, report investigations that look at the ways in which ICT tools are developed to satisfy their educational objectives, and consider ICT tools developed specially for raising environmental awareness and education.

2.3 ICT tools for environmental awareness

2.3.1 Why use ICT tools?

In his paper on Environmental Information Systems (EIS) Haklay (1999) describes two types of EIS. The first of these are tools that are information systems in the strictest sense, used to store and retrieve data. The second are tools which enable the user to analyse and simulate the environment, an example being GIS. In this thesis, the former is of interest in terms of ICT tools which help to raise environmental awareness. ICT tools have a number of uses in the environmental field, and these were defined by The World Bank (1993) in a paper which explored ICT and environmental sustainability.

1. Raising awareness and sharing knowledge.
2. Environmental modelling and associated resource management and risk mitigation.
3. Environmental progress in the ICT sector
4. Enabling greater environmental sustainability in other sectors

5. Communicating in developing and enforcing policies affecting the environment

Of course, in this thesis the first of these applications is of greatest interest; the way in which ICT tools can be used to enhance individual knowledge of the environment and also the implications behind various policies. ICT has enabled environmental information to be communicated to a large and broader audience.

The use of ICT tools has a number of benefits, one is the way in which ICT tools can present information in a variety of different formats. Many ICT tools have been developed which build on the prior knowledge of the users and some focus on different learning styles. Several tools have been developed that accommodate this variation of styles (Wild and Quinn, 1998). As well as these benefits, ICT tools can support networking, information sharing and social learning (Guimãres Pereira *et. al.*, 2003),

Of particular interest in this thesis are ICT tools which raise environmental awareness amongst young people, so that in the future, those individuals will grow up adopting environmentally responsible lifestyles. Some examples of these types of tool are described in the following section.

2.3.2 Examples of existing tools

During the design phases of ICT tool development, developers need to decide which form the tool will take. Current ICT tools exist in a variety of guises, for example in the form of games and challenges or as encyclopaedic-like references. Many are explorative, and provide the user with feedback.

There are a number of ICT tools designed to encourage environmental awareness in young individuals. One such example is K-World, an online environmental awareness raising package created by the Environment Agency. The user is able to interact with this tool by controlling a character which they guide through a neighbourhood. Various pieces of environmental education information is available to the user, and they can choose which areas they want to visit by commanding the character to visit different areas. This tool demonstrates themes such as wildlife, global warming (climate change

and flooding), past, present and future environments, waste (including recycling), water issues, population and food.

In this thesis four ICT tools designed around water environmental issues were explicitly studied. Although these tools are focussed upon in depth in the Methodology Chapter, they will be described here as examples of ICT tools to aid environmental education. The platforms selected are the Riverside Explorer (Environment Agency, 2000), Ecopod (Environment Agency, 2002), The Water Aid Game (Water Aid, 2000) and the Personal Barometer (Cranfield University, 2004).

The Riverside Explorer, developed by the Environment Agency (2000) is an information system designed for young people to use so that they may learn about environmental and habitat processes and issues. Users of the tool are able to explore a virtual environment in several ways, and are able to retrieve all the information they wish during just one session with the tool. This is an example of an explorative type tool, whereby the user interacts with a menu to explore different parts of the tool.

Both the format and the content of the Water Aid Game differ from the Riverside Explorer. The Water Aid Game was designed to enable the user to learn about the hardships of life in a developing country, by looking at ways in which the individuals dwelling in a small village overcome drought issues by working together. The user is given the opportunity to gain environmental knowledge by following the story of a young person who lives in the village and the difficulties that they face. From its title the user can gain an idea as to the format of this tool, but it is actually misleading. Rather than being a game, this tool puts the user in the place of a villager from a drought affected, developing country.

Ecopod (Environment Agency, 2002) and the Personal Barometer (Cranfield University, 2004) are similar in content, both being ICT tools designed to outline the problems of the over consumption of water in the home. Ecopod is a 'game' type environmental ICT tool, whereby the user has to solve various challenges and answer various water related questions. The user is also provided with ways in which water can

be conserved in the home. The Personal Barometer differs in the way it presents its information to the user. Rather than completing challenges, the user has to reflect upon their water consumption in the home and input various pieces of information into the tool. The Personal Barometer is an example of a tool that is both explorative and interactive, requiring the user to input details from their own lives. It also provides feedback as to the users' personal water consumption and provides water conservation information.

In order to fully understand the design issues associated with ICT tools, the various elements that constitute a successful tool should be considered. The next section uses knowledge acquired from the literature to discuss three aspects of tool design.

2.4 Features of ICT Tool Design and Use

A number of features of ICT design and use were identified in the literature. Although this list is recognised as not being exhaustive, the following three elements were exposed during the literature review and are discussed below.

- The Human Computer Interface
- The Deployment Context
- Strategic Objectives

The Human Computer Interface brings the user and the tool together. The deployment context is another important issue as it can be used to identify exactly how, when and why an ICT tool would be used. Finally, strategic objectives are of importance in this thesis as they describe the strategic purposes of the tool itself, so for example, one strategic objective might be to engender motivation in an individual in terms of environmental responsibility.

2.4.1 The Human Computer Interface (HCI)

Of those elements identified from the literature review, the human computer interface (HCI) is the most frequency evaluated element in terms of ICT tool assessment (e.g.

Hinostroza and Mellar, 2001; Crumpton and Harden, 1997; Clark, 1994). The definition of the user interface is described by Thimbleby (1990) as:

"those parts of computing systems that allow the person using the computer access to facilities offered by the computer"

The HCI can be broken down and indeed evaluated in a number of ways, however for the purposes of this study, four main evaluation criteria were selected:

Content Format - is the material contained within the ICT tool?
Content Structure - How are the different parts/ screens of the tool linked together?
Functionality - What can the user do with the applications and what options are available to the user?
Perception / impression - What impact does the tool have on the user?

2.4.2 Tool Deployment

The second element to be considered was the deployment characteristics of the ICT tools, of which two important questions were asked:

1. What is an appropriate role for ICT tools in terms of the timing and format of use?
2. What complimentary knowledge/ skills/ support is required for effective ICT deployment?

The first question addresses the point at which a tool should be utilised during an environmental education process. When is the optimum time for tool deployment and how can it best compliment the curriculum for example? The second question focuses on the necessity to identify the types of knowledge, skills and support required to enable effective ICT deployment. What specialist knowledge or experience is required in order to ensure that a session involving an ICT tool would run smoothly? Other deployment considerations would include whether the tool is designed for use by an individual, or a group and whether a tool would be used in one location, for example in one classroom, or in a more dispersed manner. ICT tools may either exist as a single tool or a suite of

tools, which has implications for the deployment context, as well as whether one tool would be referred to on a single occasion, or a number of times. The tools designed to support environmental awarness might be designed to accompany an instructional situation and could therefore be designed to be used in a facilitated or unfacilitated context. Finally when designing ICT tools of this nature, the developer would need to consider whether the tools would be dispersed to the wider public, or would just be used by teachers in a classroom setting for example.

The importance of considering teachers opinions and perceptions of ICT tools for education was also highlighted by Hawkey (2002). The view of teachers regarding ICT tools are important due to their role as facilitators during classroom teaching. During a conference Hawkey conversed with different teachers and identified three views:

- The first was concerned with technical matters relating to browsers and search engines.
- The second focussed on deployment and saw ICT tools as a means of transferring knowledge easily and more quickly to a large audience.
- The third group reflected on the opportunities ICT tools provided for new pedagogies.

Hawkey also considered the place of ICT tools in and out of school, where users would interact in facilitated or unfacilitated conditions (Table 2.3, Hawkey, 2002).

Table 2.3 Learning processes utilising ICT tools in different environments (Hawkey, 2002)

Learning considerations	School	ICT	Beyond
Why?	Convention and convenience; socialisation; imbue values. Knowledge, traditions	Variety of learner dependent motives	Learners desire to enhance and enrich their experience; learning for its own sake
What content?	Curriculum / deficit/conformist	Provider content / learner needs	Mission of provider/desires of learner
Where location?	Classroom	Home/workplace/ informal setting /classroom	Informal learning environment, e.g. museum/home
Who decides?	Teacher (with students?)	Learner	Learner
Who learns?	Identifiable student cohort	Anyone with access	Anyone with motivation
When?	Monday – Friday, 09.00 – 16.00, term time only	Anytime	Varied depending on provider and learner
How?	Organised sessions; may use 'push' technologies	On demand	On demand (may include formal sessions, e.g. broadcasts or formal lectures.

Although this is a useful overview of the use of ICT tools in both a classroom and home setting and goes further to suggest future contexts, Hawkey does not identify the limitations of such ICT tools, for example when considering his '*who learns*' question Hawkey responds '*anyone with access*'. Many individuals may want to learn, but for various reasons could be without the facilities that would enable them to do so.

2.4.3 *Strategic Objectives*

The literature review revealed a number of common objectives which all appear to be relevant in the context of environmental awareness. These included motivation, (commitment), learning (education), justice, openness, inclusion and trust. Such objectives could also be used as potential strategic objectives of ICT use.

2.4.4 *Scoping study on features of ICT design and use*

The selection of a focus for the formal evaluation of ICT tools occurred in two stages. First it was necessary to re-visit the overall aim of the project, which (as will be remembered from Chapter 1) was a desire to investigate the practical usefulness of ICT tools to support environmental awareness. Table 2.4 reports the outcomes of three small scoping studies designed to explore the potential for further development of each of the design elements discussed above.

The HCI and the Deployment Context were eliminated from further investigation due to difficulties in formulating a robust and relevant research activity. Work then began on the identification and evaluation of ICT tools in terms of strategic objective promotion. A very limited amount of work has been carried out in this area

Table 2.4 The outcomes of three small scoping studies designed to explore the potential for further development of each of the design elements

ICT Element	Description of scoping study	Take forward to full study	Reason
Human Computer Interface	Two respondents were asked to evaluate The Riverside Explorer and two to evaluate Ecopod. Evaluation involved asking questions about ICT tools to test prior knowledge followed by interaction with one of the ICT tools. After tool use questions designed around the elements of the human computer interface were asked.	✘	Potentially useful results were gained, but the evaluation results did not help in identifying how useful the tools were. Most responses were related to whether respondents 'liked' the platforms and focussed on ease of use. The format, structure and functionality could be evaluated without a user and are, in isolation, too focussed on technology rather than impact.
Deployment Context	Scoping study could have involved looking at the way in which ICT tools were deployed to aid young people in environmental awareness	✘	Would have been difficult to evaluate ICT tools in terms of deployment. Would have to determine which schools were currently using certain ICT tools and when according to certain lessons.
Strategic Objectives	Study involved two respondents and were required to fill in a self complete questionnaire, discuss a platform specific pre interaction scenario, interact with the ICT tool (Riverside Explorer), fill in an identical self complete questionnaire and finally discuss a platform specific post interaction scenario.	✓	Evaluation sessions were simple to organise and execute, and it would be easy to obtain computers with the appropriate software to run the tools. Also adopting a questionnaire and discussion approach enabled the structuring of the evaluation sessions, so that a schedule could be determined.

2.5 Identification of Strategic Objectives

2.5.1 Initial identification of strategic objectives

Investigations into the strategic objectives of ICT tool use began with a targeted literature review. This is partially reported earlier in the chapter, but is extended on the following pages. Identification of the strategic objectives to be tested took place by carrying out a targeted literature review, the results of which are presented in Table 2.5.

Table 2.5 Summary of the strategic objectives together with associated references.

Strategic outcomes	Reference
Learning	- Barr, S (2003) Strategies for sustainability: citizens and responsible environmental behaviour. *Area*. **35.3**, 227-240 - Grob, A (1995) A structural model of environmental attitudes and behaviour. Journal of Environmental Psychology. **15**, 209-220. - Borden, R.J., Scettino, A.P (1979) Determinants of environmentally responsible behaviour. *The Journal of Environmental Education*. **10**, 35-39. - Schahn, J., Holzer, E (1990) Studies of individual environmental concern, the role of knowledge, gender, and background variables. *Environment and Behaviour*. 22, 767-786. Hines *et. al.*, (1987) - Stern, P (1992) What psychology knows about energy conservation. *American Psychologist*.47, 1224-32. - Costanzo, M., Archer, D., Aronson, E., Pettigrew, T (1986) Energy Conservation behaviour: the difficult path from information to action. *American Psychologist*, **41**, 521-8 - Hawthorne, M., Alabaster, T (1999) Citizen 2000: development of a model of environmental citizenship. *Global Environmental Change*, 9, 25-44. - Draper, S.W., Brown, M.B., Henderson, F.P., McAteer, E (1996) Integrative evaluation: An emerging role for classroom studies of CAL. Computers and Education. **(26)** 1-3, 17-32
Trust	- Simon, S (2004) The emergence of social learning from environmental ICT prototypes
Motivation	- Simon, S (2004) The emergence of social learning from environmental ICT prototypes - Barr, S (2003) Strategies for sustainability: citizens and responsible environmental behaviour. *Area*. **35.3**, 227-240 - Grob, A (1995) A structural model of environmental attitudes and behaviour. Journal of Environmental Psychology. **15**, 209-220. - De Young, R (1996) Some physochological aspects of reduced consumption behaviour: the role of intrinsic motivation and competence motivation. Environment and Behaviour. 28, 358-409. - De Young, R., Kaplan, S (1985-1986) Conservation behaviour and the structure of satisfactions. *Journal of Environmental Systems*. **15**, 233-42. In: Barr, S (2003) Strategies for sustainability: citizens and responsible environmental behaviour. *Area*. **35.3**, 227-240

	- Kaiser, F.G., Shimona, T.A (1999) Responsibility as a predictor of Ecological Behaviour. *Journal of Environmental Psychology*. **19**, 243-256.
Inclusion	- Simon, S (2004) The emergence of social learning from environmental ICT prototypes
Justice	- Maiese, M. (2003) *Beyond Intractability, Distributive justice*. [Online]. Available from: http://www.intractableconflict.org/m/distributive_justice.jsp (2003) [Accessed 10 September, 2004]. - Selwyn, N (2000) Researching computers and education –glimpses of the wider picture. *Computers and Education*. **34**, 93-101
Openness	- Grob, A (1995) A structural model of environmental attitudes and behaviour. Journal of Environmental Psychology. **15**, 209-220. - Duncker, K (1963) *Psychologie des productiven* Denkens. Berlin: Springer. In: Grob, A (1995) A structural model of environmental attitudes and behaviour. *Journal of Environmental Psychology*. **15**, 209-220

A shortlist of six selected strategic functions were composed. These comprised the promotion of:

1. Learning (education)
2. Trust
3. Motivation (commitment)
4. Inclusion
5. Justice
6. Openness

It was necessary to develop a shortlist of strategic objectives for a number of reasons. Time was a major factor and by focussing on six main objectives, an in-depth investigation could be carried out on a few, rather than a relatively quick analysis of a large number of objectives. In the original shortlist education took the place of learning, and commitment in place of motivation, but these were subsequently changed to learning and motivation for reasons explained in Chapter 3.

The identification of the six strategic objectives was the first step towards the thesis goals, but careful consideration regarding the definitions of the selected objectives was required. Section 2.5.2 addresses each strategic objective in detail, providing a definition and brief discussion of its salient features.

2.5.2 Strategic objectives

The literature review revealed a number of common objectives which all appear to be relevant in the context of environmental awareness. These included motivation, learning, justice, openness, inclusion and trust. The way in which these themes appear in the literature and their relevance are discussed in this section of the chapter.

2.5.2.1 Motivation

Motivation is defined by the Collins English dictionary as:

'The act or an instance of motivating, the desire to do; interest or drive.'

For the purposes of this thesis, 'Motivation' is defined as the level of desire individuals have in adopting more sustainable lifestyles. Are all participants committed to both learning how to adopt more sustainable lifestyles and implementing these actions? Initially 'commitment' was on the shortlist of strategic objectives, but this was subsequently changed to motivation. Evaluating ICT tools in terms of promotion of commitment would have been problematic using the evaluation session / questionnaire approach, as an individual's commitment would have to be tested over a period of time. Therefore motivation was tested in terms of the ICT tools and the degree to which ICT tools influenced whether individuals adopted more sustainable lifestyles.

Whilst Barr (2003) was conducting his in depth review of the factors which effect environmentally responsible behaviour, he found that motivation was one such psychological variable. Specifically, intrinsic motivation was considered to be a factor which appeared to play a role in determining whether an individual exhibited pro environmental behaviour. De Young and Kaplan (1985-1986) found that individuals, who gained a feeling of satisfaction by recycling for example, were more likely to continue practising environmentally responsible behaviours. De Young (1996) also found that motivation and commitment were linked in terms of intrinsic motivation. When conducting an investigation into intrinsic motivation he found that an individual possessing a high amount of intrinsic motivation gained a sense of well being and self worth, this therefore contributing to the individual becoming more committed to behaving in a more sustainable way in the future.

Also linked to motivation, Kaiser and Shimoda (1999) looked at the way in which environmental responsibility is a predictor of environmental behaviour. They identified that a person can either feel morally responsible or conventionally responsible, where moral responsibly depends on a person's self ascribed responsibility (a deliberate responsibility judgement) or guilt feelings. Conventional responsibility depends on

social expectations a person is aware of and his readiness to fulfil these expectations. Kaiser and Shimoda (1999) found that if people feel guilty for what they do or fail to do, they also feel morally responsible for the environment. This promotes their self ascription of responsibility and it is this judgement that predicts a considerable portion of a person's ecological behaviour.

2.5.2.2 Learning

'Learning' is described in The Collins English dictionary as:

'Knowledge gained by study'

This strategic objective first manifested itself in the form of 'education', but due to the levels of complexity associated with this term, 'learning' was considered to be a more straight forward and appropriate strategic objective to include in this context. Education for example, implies both teaching and learning, or the exchange of information from one individual to another. Rather than focussing on the teaching aspect of ICT tools, or indeed this exchange between the pedagogue and the learner, a user centred approach was adopted where the degree to which learning was promoted by certain ICT tools was analysed.

Environmental education tools can be used to empower the individual so that they are able to be environmentally aware. They are able to make informed choices that will lead to them living environmentally responsible lifestyles. A central consideration is that the tool would need to be able to cope with different learning needs and allow users to decide the level of information (in terms of difficulty) in what they are able to view.

A number of authors (Grob, 1995, Barr, 2003, Borden and Scettino, 1979, Braun 1983) have conducted investigations which reveal that if citizens are knowledgeable regarding an environmental issue, or are prepared to learn about ways in which an environmental issue can be remedied, then they are more likely to adopt environmentally responsible behaviour. In his model of environmental behaviour Grob (1995) included factual

knowledge about the environment as one of the sub components and environmental problem recognition as the other. Both of these identify the importance of learning in raising environmental awareness and in encouraging environmentally responsible behaviour. Similarly, in his review of the literature, Barr (2003) identified that different processes exist by which knowledge is acquired and understood. Schahn and Holzer (1990) identified two different types of knowledge when attempting to determine environmental action and these were termed abstract and concrete. Abstract environmental action relates to the knowledge regarding environmental issues, for example, causes-problems-solutions. Concrete action relates to the knowledge that the individual acquires which would help them to act in an environmentally responsible way. There has been much debate as to which type of knowledge is more likely to lead to environmentally responsible behaviour, Schahn and Holzer positing that concrete knowledge was more likely to do so, whereas Hines *et. al.*, (1987) argue that abstract knowledge was more significant. Other authors focussed on different aspects of this field. For example Stern (1992) suggested that the source of knowledge was an important factor, whilst Costanzo *et. al.*, (1986) focussed on the way in which information was gathered as an influence on environmental awareness and behaviour.

The work by Stern (1992) and Costanzo *et. al.*, (1986) is directly linked to the environmental information component identified by Hawthorne and Alabaster (1999) in their work on environmental citizenship. They found from previous research that environmental information was often acquired by individuals through the media, but the information was often highly technical and complex, imprecise and usually biased. In contemporary society, environmental information is available in many places, and looking for relevant information may seem a daunting task. It also may be more difficult for some groups of people then others to acquire such information. An individual's success in gathering information depends on whether the individual knows where to look, if they have the confidence to ask for information, whether they understand it when they get it (or if help is available for them to understand it) and whether they are able to afford the information if they need to pay for it.

2.5.2.3 Justice

According to the Collins English dictionary, Justice is:

'The quality or fact of being just.'

'Being Just' is defined as:

'Fair or impartial in action or judgement.'

Justice is promoted by the inclusion of all interested parties so that every concerned individual is able become both more environmentally aware and responsible.

Therefore including this strategic objective will test the ability of the platform to instil a sense of justice amongst users, but this is not solely dependent on the platform itself, but also the process. 'Justice' can be split into two main types, according to Maiese (2003):

'Distributive justice is concerned with the fair allocation of resources among diverse members of a community. Fair allocation typically takes into account the total amount of goods to be distributed, the distributing procedure, and the pattern of distribution that results.'

'Procedural justice is concerned with making and implementing decisions according to fair processes. People feel affirmed if the procedures that are adopted treat them with respect and dignity, making it easier to accept outcomes they do not like.'

Within this investigation, procedural justice is of specific interest, but future studies in ICT tool design could focus more on issues concerning distributive justice. To measure this strategic objective, the characteristics of a just outcome need to be determined and understood.

2.5.2.4 Openness

To be open is defined by Collins as:

'able to be obtained, available'

Openness can be used to determine the receptiveness of individuals to new ways of thinking.

In his model of environmental behaviour Grob (1995) included 'openness' as a sub component and deduced that this component was vital in terms of an individual's openness to new ways of thinking. If an individual is very closed minded with regards to changes to their lifestyles, or adopted rigid lifestyle patterns, which they would be very resistant to change, then they are going to be less likely to adopt environmentally responsible lifestyles. However, the factors which contribute to adopting an environmentally friendly lifestyle may go further than Grob suggests, as he makes no mention of the time or monetary constraints that could be governing factors in many individual's choices. Another of Grob's assumptions, which is relevant in this case is the more creative a person was in helping to come up with environmental solutions, the more appropriately they would behave in terms of being environmentally responsible.

In the case of 'openness', ICT tools will be evaluated in order to determine the degree to which openness is promoted, which, for the purposes of this thesis, is defined as an individuals openness to new ways of thinking.

2.5.2.5 Inclusion

To include according to the Collins English dictionary is:

'To add as part of something else; put in as part of a set, group or category.'

and inclusion is therefore:

'The act of including or the state of being included.'

In the context of this study, 'inclusion' is taken to indicate feeling part of an issue or problem and having a sense of problem ownership. These are important issues, not only for environmental responsibility, but also in the context of public participation.

2.5.2.6 Trust

The Collins English dictionary describes trust as:

'Reliance on and confidence in the truth, worth, reliability, etc,. of a person or thing.'

One of the aims of environmental education based ICT tools is to dispel the mistrust of the government, industry and regulators that non experts may have. By focussing on communication, a specific tool and / or process could be used to provide a link between different stakeholders, hence encouraging both trust and transparency.

When considered as a strategic objective of ICT tool use, trust can be broken down into three types:

1. Trust in the institution that developed the ICT tool.
2. Trust in the information presented in the tool.
3. Trust in decisions based on use of the tool (in this case to encourage environmentally responsible behaviour).

The first two types of trust listed; trust in the institution that developed the ICT tool and trust in the information presented in the tool are inextricably linked. For example, if a user was seeking to become environmentally responsible but did not trust a tool that they were using to help them do this, then they may not get very much out of the experience.

The final aspect of trust - trust in making decisions- addresses a very different issue. After using an ICT tool to learn about a certain environmental issue, does the user feel confident enough to apply their newly acquired knowledge to a real life situation. Specifically, do they have the knowledge and confidence to implement a lifestyle change? The pressures of gaining knowledge and then applying it to a real life situation must be considered. If users have no trust in their ability to manipulate and utilise provided information, then the ICT tool designed to promote this has failed in its task.

2.6 Agendas for Strategic Objective Evaluation

Much work has been conducted on the evaluation of ICT tools in terms of usability, (Mack and Nielson, 1994., Parlangeli *et. al.*, 1999., Collings and Pearce 2002., Huart *et. al.*, 2004). However, in comparison, very little work has been conducted which focuses on the human, or social side to educational ICT tools. In recent times it has become obvious to some researchers that wider questions need to be asked in terms of educational computing (Selwyn, 2000), where traditionally work has concentrated on whether educational ICT tools achieve their educational outcomes, or whether they fulfil their usability objectives.

In this thesis, the focus is on environmental ICT tools and their evaluation in terms of certain identified strategic objectives. An extensive literature review revealed the lack of work conducted specifically in this area. However, by taking a wider view of educational ICT tools and reviewing both traditional and novel evaluation methods, a limited amount of information relevant to this thesis was collated.

In his recent paper, Selwyn (2000) identified a need to conduct more qualitative investigations in the field of educational ICT, as well as a gap in the research as far as large scale investigations were concerned. He also highlighted that although a number of investigations utilise quantitative methods, which tend to answer what has 'happened and what could happen' questions, the focus should be on what does actually happen at the time. The use of both quantitative and qualitative data can complement each other, qualitative data can be used to highlight quantitative data, and as Selwyn suggests, can reduce the need for subjective interpretation.

Selwyn also suggested that research in this area should consider and explore alternative perspectives of society and technology in terms of educational computing and move away from solely concentrating on what he calls the 'linear cause and effect model of

technological and social determinism' which he sees as a weakness in education computing research. Qvortrup in 1984 had the view that computing:

"cannot be properly understood if we persist in treating technology and society as two independent entities"(Selwyn, 2000).

Selwyn concluded that it was clear that future research in the area of educational computing should not consider technology or society as separate entities, or draw a technological/societal distinction, but rather should focus on the various social contexts in which the ICT technologies are developed. He describes these alternative perspectives of society and technology as social, cultural, political and economic. Within the social aspects, he considers the perceived neutrality that many researchers consider technology to be a nonsense, and discusses the way in which advocates in this field consider educational computing to be a great benefit to social justice. However, rather than ICT technology aiding in the dissemination of information, and closing the gap between the information rich, and the information poor, Selwyn recognised that the gap was actually widening. He therefore concluded that when considering social aspects, an understanding of the factors leading to the different levels of access to, and exclusion from educational ICT tools should be considered.

In his conclusions, Selwyn recognises and acknowledges the good work conducted by educational computing researchers over the past years and states that his aim is not to dismiss past investigation in this area. His aim was to outline the importance of considering other aspects, be they social, economic etcetera when developing technology and he suggested that a multidisplinary approach to educational ICT design, (which would involve experts in human computer interaction and cognitive psychology, social and cultural studies and finally human geography for example) would be most beneficial. If researchers consider these factors it will work to strengthen educational computing research.

Selwyn's work outlines the need to consider both technology and the sociological aspects to ICT tool design and use. This thesis considers the sociological aspects of ICT tools, by focussing on the strategic objectives, but also allows for the consideration of certain technical aspects.

Other researchers have recognised the need to consider both technological and social aspects when creating new technologies for education. In her paper which looked at why and how systems approaches can help in the evaluation and design of new ICT tools as social learning platforms, Simon (2004) considered a number of sociological as well as technological aspects. Examples of the technological and sociological aspects Simon considered included whether the tool evaluated presented issues relevant to the users, whether meanings were clearly explained in the tool for example and also in her work Simon scrutinised the pedigree of the ICT tools content.

Simon identified that there were certain desirable objectives that ICT tools designed with a social learning focus should promote, including learning, motivation, and trust. In terms of motivation, Simon considered whether users of the ICT tools evaluated were likely to be motivated to reuse them. Another influence which she studied was whether the tools would motivate the users so that they would go on to consider wider environmental issues. She also discussed the way in which emotional involvement was an important factor when considering motivation; the more motivated an individual may be to learn about an issue, the more they will feel about an issue. The final aspect of motivation that Simon considered was with regards to social learning, and if a group needed to use an ICT tool in order to reach a consensus as to the best solution to an environmental problem, would the group be motivated long enough to find the best option through use of the ICT tool in question.

Trust was another issue considered by Simon, not only trust in the content of the ICT tools themselves, but also in terms of social learning, specifically in the process itself as well as the trust that the individuals involved in the process have in others taking part. In relation to trust, Simon also recognised the influence of bias. She considered this in

terms of the way in which differing perspectives and issues present themselves in society and need to be addressed. As well as 'motivation' and 'trust', inclusion is also hinted at in her paper. In the same way as Selwyn stated that more needed to be done in order to close the gap between the information rich and information poor (Selwyn, 2000), Simon considered that there is a need to bridge the knowledge gap between experts and non experts that may be involved in a social learning process. By doing so, the opportunities for non experts to take part in a social learning process are increased. Other work conducted in this area in terms of bridging the knowledge gap was conducted by Forrester (1999). Specifically related to stakeholder engagement processes, he suggests that scientific and lay knowledge should be treated equally. He provides evidence to suggest that scientific knowledge is 'pre-eminent', or that the general opinion amongst scientists or experts is that science is of more worth than lay or local knowledge. Contrary to this belief, he suggested that scientific knowledge sometimes is incomplete and to choose not to take into account or learn from local knowledge displays ignorance on the part of experts.

Simon also conducted brainstorming sessions in order to evaluate ICT tools, and this in turn uncovered a number of other objectives which warranted consideration. Involving tutors from the Open University, brainstorming sessions focussed on a number of different issues, including the evaluation of ICT tools in terms of participation. The group considered the ICT tools to be useful in providing up to date information, but expressed concerned regarding the content itself in terms of relevance, trust, quality and presentation. As well as these issues, the group also considered the end users of the tools and who these individuals might be. In a second brainstorming session, the group considered motivation in terms of learning. Devising a set of 'motivation ingredients', the tutors discussed the way in which ICT tools should be designed in order to ensure that knowledge is retained and understanding is gained from using the ICT tools in question. The tutors identified that interaction was key to motivation to learn.

Evaluations to gauge learning following the use of ICT tools occur more frequently in the literature, one example being the work of Scanlon *et. al.*, (1998). Specifically

focussed on learning, Scanlon and his team looked at how computers can have an impact on learning, and evaluated a number of different ICT tools, such as tutorial packages and simulations. They stated that learning outcomes must be considered in order to assess the effectiveness of any program, but changes to learner's perceptions and attitudes were also important. Basing their evaluations on the CIAO (Context, Interactions, Attitudes and Outcomes) framework, Scanlon *et, al.,* (1998) adopted a pre and post testing methodology to evaluate tools in terms of achieving a set of learning objectives. It was concluded that in order to conduct meaningful evaluations, the individual student (in terms of learning needs), the tasks set and the intention of the teacher or instructor must be considered. Research would also need to consider individual learning outcomes and students perceptions of any learning task set, their level of engagement, their interactions and the teachers intentions. The overall conclusions reached by Scanlon *et, al.*, (1998) were that in future researchers in this area need to consider not only the learning outcomes and what the students actually learnt, but how the learning has taken place.

Similar to the work of Scanlon *et, al.,* (1998), Draper *et. al.,* (1996) also considered learning as an objective. Their team evaluated a number of ICT tools over a two and a half year period, also adopting a pre and post testing methodology. Their overall conclusions were that integrative evaluations were beneficial in that they can help teachers make better use of existing available ICT tools, rather than opting for other pieces of software.

In conclusion, although there is limited work conducted specifically in the area of environmental ICT tools and the way in which these could be evaluated in terms of certain strategic objectives, a small amount of information was found when a wider view of educational ICT tools was taken. Previous work conducted by authors such as Simon (2004), Scanlon *et, al.,* (1998) and Draper *et, al.,* (1996), utilised certain methodologies that were considered for this thesis investigation. For example, Simon adopted a methodology involving brainstorming and discussion. Both Scanlon *et, al.,* (1998) and Draper *et, al.,* (1996), used pre and post testing in order to determine

whether certain ICT tools promoted learning. Both of these methodologies are considered during Chapter 3, and the pre and post testing was adopted in this study.

2.7 ICT Tool evaluation options

Educational ICT tools can be evaluated in a number of ways. From the literature the most widely featured focus for the evaluation of ICT tools is the Human Computer Interface (HCI) and the usability of the tool. Most established test and evaluation methodologies are consequently targeted at this aspect of ICT design. However, on going assessment of ICT tool impact and iterative improvement of functionality and design needs to be driven by effective evaluation. There are a number of different approaches to the evaluation of ICT tools and these fall into two main categories depending on the objective of the evaluation. 'Formative' evaluations are used to strengthen or improve whatever is being evaluated (in this case an ICT tool) whereas 'summative' evaluations focus on the effects or outcomes of ICT tool use (Trochim, 2002).

As noted above, many of the evaluations reported in the literature focus on the usability of the tool itself, that is, how easy and usable the platforms in question are. Four enquiry methods are identified by Mack and Nielson (1994) (in Huart *et. al., 2004*) which are 'formal' methods, 'automatic' methods, 'empirical' methods and 'informal' methods (See Table 2.6). This thesis investigation looked at the way certain strategic objectives were promoted, and to do this, empirical methods were adopted. These included use of questionnaires, interviews and user testing and is discussed in Chapter 3.

Table 2.6 The different ways in which the usability of ICT tools can be tested (Huart *et. al.*, 2004).

Method	Process	Limitations
Formal	Take usability measurements	Are difficult to use, none exist to evaluate multimedia tools.
Automatic	Use systems to take measurements. For example 'The display analysis program', which records information within a multimedia application. Many are designed to record the accessibility, readability, and coherence of pages of websites.	Limited use at present
Empirical	Include the use of questionnaires, interviews and user testing.	Difficult to get a representative sample, may be problems associate with cost and implementation.
Informal	Based on heuristics, recommendations and rules. The respondents are normally experts and although they take less time and cost less to complete.	They are considered less efficient than empirical methods.

Focussing on usability issues, Parlangeli *et. al.*, (1999) carried out an evaluation which investigated the potential impact which had on learning. The authors hypothesised that if a multimedia tool was difficult to navigate, this would have a negative impact on learning. Three studies were carried out in this investigation, the first two evaluating the usability of a multimedia system (which in this case was an online distance learning course), whilst the third involved the evaluation of the tool using three sets of students. During the third study, one group interacted with a multimedia CD (which was identified as a poorly usable system following a previous investigation); one group used the printed pages that accompanied the CD, but with the CD removed and a third group used a traditional book (and were considered to be the control group). The students were required to fill out a questionnaire before tool interaction and then take part in the learning phase. Following this the students were required to take a test to determine which method was the best at fostering learning and then the CD group were required to fill out one final questionnaire. The results indicated that the hypothesis was correct, that learning was affected by the tool's poor usability. It was concluded that in future,

work would need to be carried out to determine exactly how much learning is affected and to determine the cognitive processes which cause such results.

An alternative distinction was made between the two main types of evaluation processes by Collings and Pearce (2002); 'heuristic' evaluations involving the assessment of interfaces by experts and evaluations involving users (non-experts) who interact with the tools and provide feedback. Usually when undertaking the latter, users are asked to complete tasks that would demonstrate the way in which the tool works.

Other evaluation approaches include the remote assessment of websites, which entail the use of software applications to collect data and may require the provision of bulletin boards to allow evaluators to give their opinions regarding the site. Evaluation techniques which allow remote users to take part in assessment sessions are beneficial because they allow multinational users to take part and many can be conducted whenever users have spare time available. However, certain interesting aspects may be lost if this remote approach is adopted. For example it doesn't allow the investigator to witness the process that an evaluator may go through during an evaluation, unless video conferencing is available (Collings and Pearce, 2002) .

In their investigation, Collings and Pearce (2002) had the unique opportunity to involve groups of students from two universities in an evaluation exercise which looked at the way in which feedback was a valuable method for the evaluation of websites. The students were required to design websites and a set of usability heuristics were proposed and agreed by the two universities. These focussed on the human computer interface element and imposed the following requirements;

- Users should be kept informed where they are and where they should go.
- There should be appropriate use of language and media
- User friendly navigation control
- Consistent design throughout site; following conventions
- Error Prevention

- Recognition rather than recall
- Allow the user to customise the site to their own needs
- Aesthetic and minimalist design
- Error messages to be expressed intelligibly
- Help and documentation

The students from both universities designed websites and then evaluated each others applications, providing feedback. The students were then able to modify their websites on the strength of the feedback given. From this study it was concluded that this method of evaluation was useful in terms of assessing the usability of websites and allowing the students to gain experience of carrying out evaluations. Uniquely the students had two roles in the evaluation, as both developers and users. This investigation showed the importance of the careful evaluation of ICT tools and why it was beneficial to involve the end users in the development and evaluation of the tool itself. This thesis investigation utilised the empirical methods adopted by Collings and Pearce (2002) where they involved the end users.

The problem of usability features becoming more highly considered at the expense of educational issues was investigated by Jones *et. al.*,(1999). Comparing the way in which evaluations differ when carried out by individuals in the educational community and those involved with HCI, Jones *et. al.*, (1999) proposed a model to evaluate computer assisted distance learning. Being members of the educational community, the investigators created the Context, Interactions, Attitudes and Outcomes model (CIAO). The results showed that this model enabled them to determine which elements were salient for certain applications. The utilisation of the CIAO model allowed the researchers to focus on both the teaching and learning context by looking at different aspects of the processes and products. It was concluded that *"the ultimate objective for educational software is that it should be educationally beneficial and it is exactly in such environments that it is important to track how usability contributes (or not) to educational goals."* (Jones *et. al.*, 1999)

An evaluation method to help students decide which websites were the best to assist them in learning was developed by Hwang *et. al.*, (2004). The investigators looked at the existing procedures by which websites are evaluated, including vote orientated websites where users could provide feedback as to the usefulness of each site. Other students were required to rate certain aspects of a website and this information was then used by students to evaluate the site's usefulness. However, there are a number of problems with this system as identified by the authors:

- The users are only able to give their impressions of the tool, which may result in the omission of important criteria, such as user interfaces, functionality and content quality.
- All web sites should not be evaluated using the same criteria because they differ in purpose and usage.
- It is unlikely that all users would be able to evaluate the websites focussing on all the criteria.
- The users would not have assistance available to them when they are evaluating the websites.

To overcome these problems the authors proposed a group decision approach, utilising several computing approaches such as fuzzy theory, grey system and group decision method. The findings allowed the investigating team to develop an Educational Web Site Evaluator (EWSE) to identify potentially useful websites.

Triangulation methods could also be adopted for the evaluation of ICT tools; but are also used in a variety of research fields. Traditionally used in navigation to determine the exact position of an aircraft by using several reference points, triangulation can also be applied to evaluation (Ammenwerth *et. al.*, 2003). In this context, triangulation would entail the use of a number of different data sets, methods, observers or theories to assess ICT tools. Four methods of triangulation exist, including 'data' triangulation, 'investigator' triangulation, 'theory' triangulation and 'methods' triangulation. As its name implies, 'data' triangulation is the use of various sources of data with regards to

time, space or people. 'Investigator' triangulation involves the participation of observers or interviewers taking part in a study where they would study gather and analyse the data together. Various perspectives, hypotheses or theories are used when 'theory' triangulation is carried out and finally an evaluation employing a number of methods for data collection and analysis is termed 'methods' triangulation (Ammenwerth *et. al.*, 2003). These methods can only be applied when focussing on a single research question.

From the literature reviewed concerning evaluation, it has become clear that although a number of evaluations have been carried out on various multimedia applications, these focus solely on the human computer interface aspects of the applications. In conclusion, this literature review has considered the role of sustainable development and environmental awareness in the context of education. It has outlined the structure of existing ICT tools and from this the focus of the thesis was developed which is the evaluation of ICT tools in terms of the promotion of certain strategic objectives relating to environmental awareness. Finally, an overview of the methodological options for the evaluation of ICT tools in terms of strategic objectives was presented, followed by the options for the evaluation of ICT tools in general.

2.8 Specific aims and objectives of the study

The strategic objectives identified in this research agenda will be the focus of the main study and the aims and objectives of this investigation are listed below.

2.8.1 Aims

To determine the extent to which ICT tools designed to support environmental awareness achieve a number of strategic objectives.

2.8.2 *Objectives*

1. To identify the main strategic objectives of relevance in the context of an ICT tool designed to aid environmental awareness.

2. To design an appropriate research methodology to determine strategic objective promotion by ICT tools. This would be in the form of an evaluation activity.

3. To test four ICT tools to determine the degree to which they promote the strategic objectives identified in 1 (above).

4. To draw conclusions regarding an evaluation methodology which could potentially be used to evaluate all future environmental awareness raising ICT tools.

5. To suggest changes which could to be made to pre existing tools in order to improve their effectiveness as tools for environmental awareness.

3 Methodology

3.1 Introduction

This element of the thesis is dedicated to an explanation and discussion of the methods by which the selected ICT tools have been evaluated to determine whether they promote the strategic objectives identified in Chapter 2. Evaluation sessions were conducted with three participant groups; (i) ICT tool developers, (ii) ICT tool users and (iii) experts in the design and use of ICT tools for environmental education and decision making.

The chapter comprises three sections. The first section provides an overview of the platforms selected for inclusion in the study, whilst the second section discusses the selection of respondents. The third section focuses on experimental design and organisation, which includes a description of the methods used, and why these were selected over other possible methods, how the evaluation itself was eventually conducted and finally the metrics used.

Because so little work has been carried out to date to determine strategic objective promotion by ICT tools (to the knowledge of the author), there are few previous studies on which to base fieldwork design. However, by taking a wider view of evaluation methods from different fields, a suitable methodology was devised. Useful literature included Bouma and Atkinson (1995), Robson (2002) Harvey (1998).

3.2 Overview of the fieldwork

In this section, the process by which the experimental aspects of the investigation were carried out are summarised. The process began with the identification of strategic objectives of tool use. As will be discussed in the following sections, both the platforms to be evaluated in terms of strategic objective promotion and an appropriate response group needed to be identified. Respondents included in the evaluation sessions included the developers of the tools selected for inclusion, the targeted user, (secondary school children between the ages of 10-16 and also postgraduate students) and finally experts in the field of environmental awareness and education. A diagrammatic representation of this process is shown in Figure 3.1.

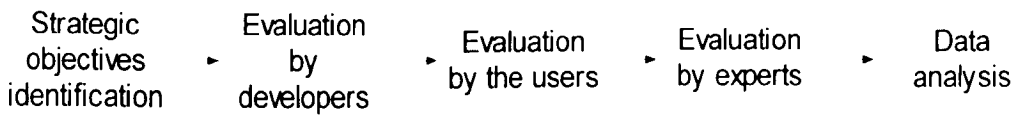

Figure 3.1 Research activities for the main study

3.3 Platform selection and descriptions

Evaluation work was carried out using pre-existing ICT tools that focus on environmental awareness, specifically water environment issues. The vast majority of tools available for use were those designed for school students, although those existing on the internet could be accessed by anyone. Three of the tools selected for inclusion in the study were designed primarily for educational use by school students, but could also be utilised by adult users. A number of criteria were imposed in order to devise a shortlist of ICT platforms.

During the project's infancy, the decision was made to only include tools developed within the UK. The aforementioned factor warranted consideration as it could particularly effect evaluation of the strategic objectives relating to trust. Asking an individual whether they trust an organisation, or the content of a tool developed by an

organisation requires that the respondents must at least be aware of the organisation in question.

The second stipulation for the platforms selected was that they must focus on a water management issue. This served to provide uniformity amongst tools as well as aiding the selection process itself. The platforms selected for the evaluation were the Riverside Explorer (developed by the Environment Agency), Ecopod (also developed by the Environment Agency), The Water Aid Game (developed by Water Aid) and The Personal Barometer (developed by Cranfield University, 2004). A short description of each of the tools is provided in the following sections.

3.3.1 The Riverside Explorer

The Riverside Explorer (Environment Agency, 2000) allows the user to explore river habitats in England and Wales. This extensive database of river habitat information is CD-ROM based and was designed for use in schools, specifically to facilitate geography, science and ICT sections of the national curriculum. It is described by the Environment Agency as:

"An interactive CD-ROM based on the Environment Agency's database of habitat features recorded during a national survey of rivers. Information on more than 4,500 river sites in England and Wales may be explored and searched by means of an easy-to-use geographic information system based on Ordnance Survey maps" (Environment Agency, 2000).

As an example of the content of the tool, a screen shot of the section entitled 'How rivers shape the land' is presented as Figure 3.2.

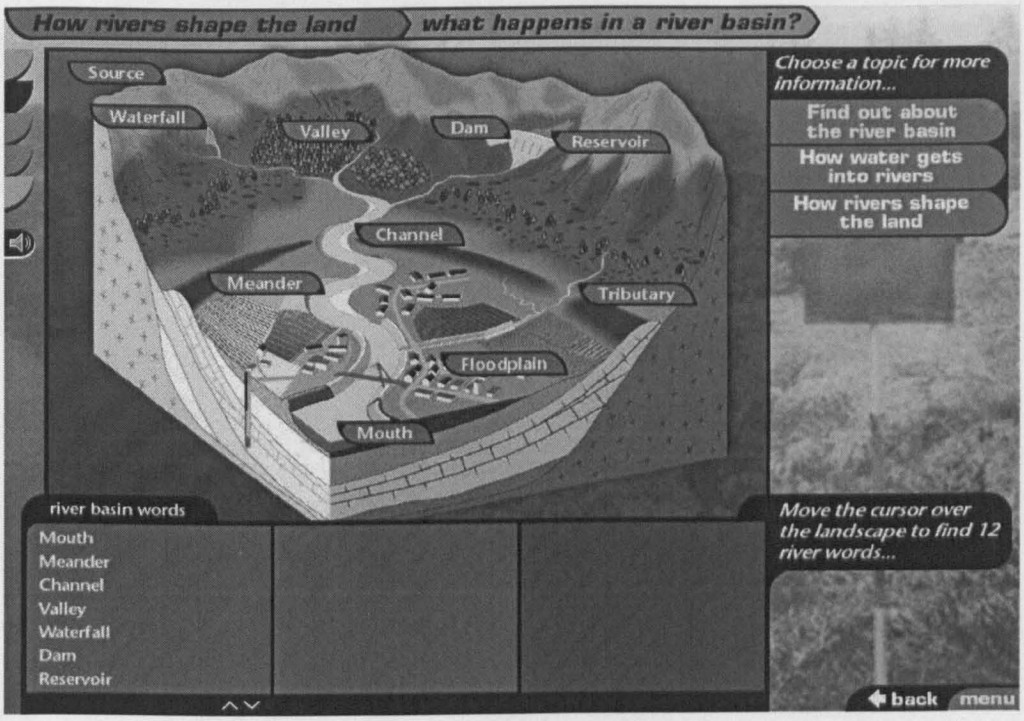

Figure 3.2 Screen shot of The Riverside Explorer (Environment Agency, 2000)

The tool itself comprises five interactive sections, but also provides a further two sections - 'Case Studies' and 'Teachers' notes'. The interactive sections are entitled:

- River habitat survey of England and Wales
- How rivers shape the land
- River wildlife habitats
- Practise a river survey
- Glossary

The 'Case Studies' and 'Teachers Notes' sections are not available on-screen but can be printed for use in the classroom.

3.3.2 Ecopod

The Ecopod platform, designed by the Environment Agency (2002), is concentrated around water overuse in the home. The application is an environmental 'game' based in the year 2020. During the opening titles the user is provided with a detailed synopsis that sets the scene and tone of the game. The user is informed that years of water misuse

have taken a terrible toll on the environment, resulting in the near depletion of our most precious resource and forcing humans to dwell in Ecopods. A firm known as 'The Federation' distributes the dwindling water supplies equally between the pods and the user is required to manage and monitor the water levels in their particular Ecopod. To illustrate the content of Ecopod, Figure 3.3 is presented.

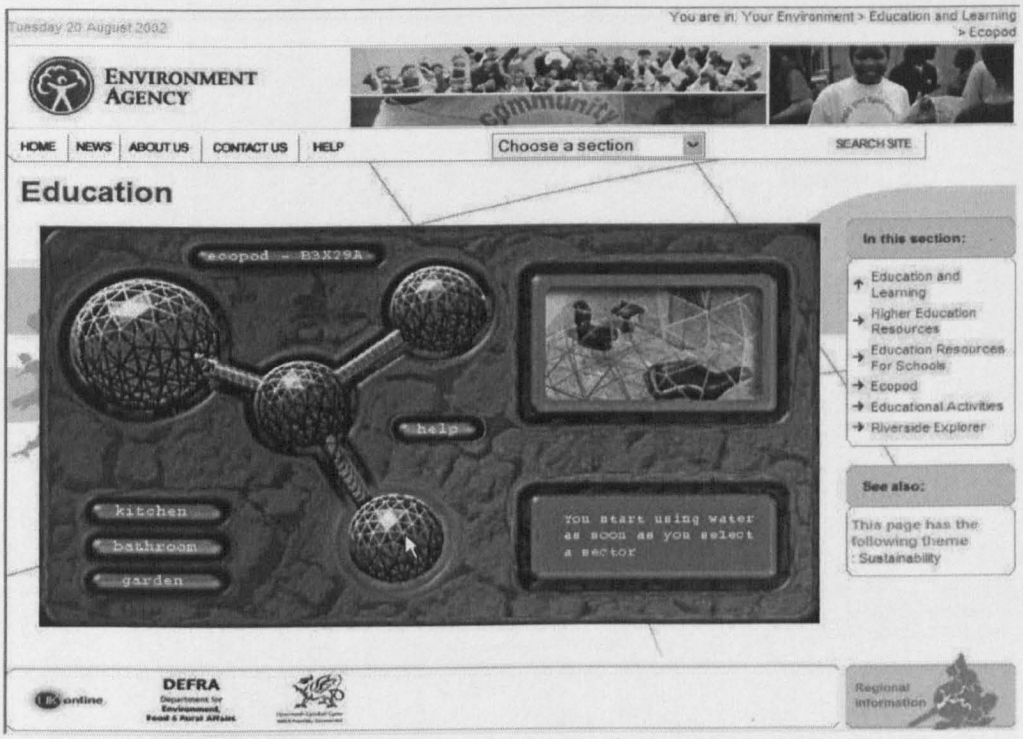

Figure 3.3 Screen shot of Ecopod (Environment Agency, 2002)

The Ecopod application is described by the Environment Agency as being an:

"Interactive space age game that challenges players to use water wisely in the 21st century. Players have to manage and monitor levels of water by working their way through a series of challenges in the kitchen, the bathroom and the garden, or risk destroying their human habitation environment, the ECOPOD" (Environment Agency, 2002).

The user saves water by successfully completing different challenges in different sections of the Ecopod. Tasks to be completed are either based on water saving in the kitchen, bathroom or in the garden. The user is therefore required to make certain

decisions during the tasks in order to conserve water. Good choices result in the user managing their water supplies efficiently, whilst bad choices result in the user managing their resources in an unsustainable way.

3.3.3 The Personal Barometer

The Personal Barometer is an application designed by the School of Water Sciences at Cranfield University as part of the project *'Social learning on Environmental Issues with Interactive Information and communication technologies' (VIRTUALIS,* contract no – IST-2000-28121, 2003). The application provides the user with:

'An estimation of their household water consumption which is calculated in terms of a water shadow (the area of land required to collect enough rainwater in a year to satisfy the water consumption of a single person in the users house'(Cranfield University, 2004).

The water shadow is calculated based on the assumption that all citizens utilise as much water as the user does. The user is able to compare their water use with the consumption figures for their selected region (area of residence in the UK), other regions in the UK and also other countries, for example Jordon and Gabon.

The calculation of the water shadow is completed by the user as they visit different rooms in a virtual house. The interactive rooms are the garden, garage, toilet, master bathroom and kitchen. As they enter each room, they are required to input an estimated number of times they or members of their household exploit each water use activity. Figure 3.4 shows a plan of the house and the areas that the user is able to explore.

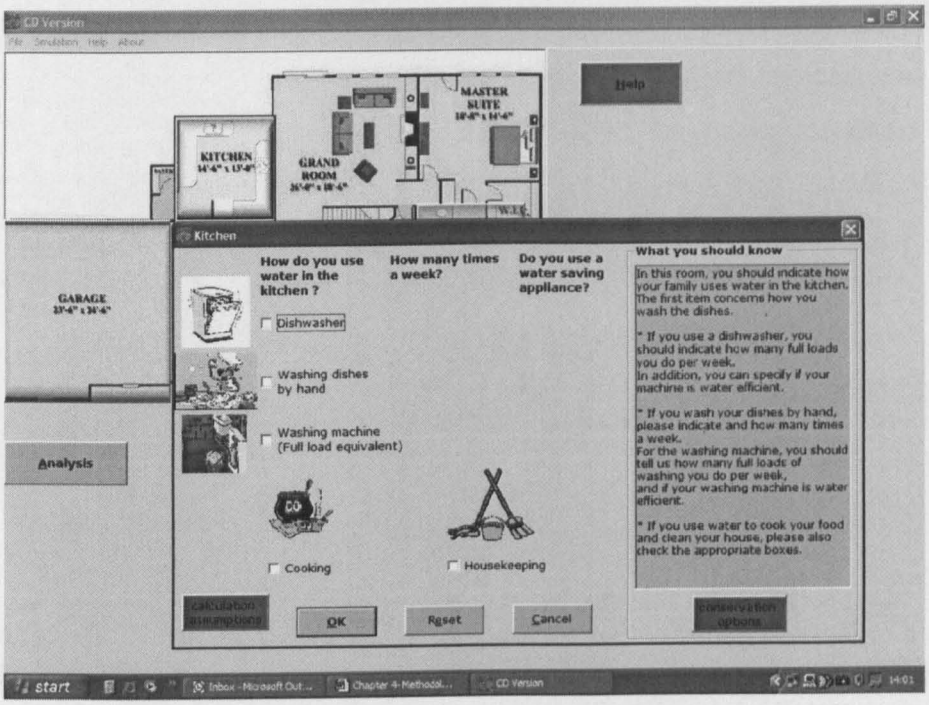

Figure 3.4 Screen shot of The Personal Barometer (Cranfield University, 2004)

To aid the user when making their estimations, calculation assumptions are provided. If the user wishes to apply what they have learnt from the tool to their water use activities in the home they are able to access suggestions are made in the conservation options section.

3.3.4 The Water Aid Game

Water Aid (Water Aid, 2000) is the final developer to be involved in this thesis investigation. They state that:

"By playing the Water Aid game, you can see how you would help villagers in Ghana, Nepal and Ethiopia build a water supply. You can see the issues and challenges that Water Aid and the villagers have to face when planning and building their water projects" (Water Aid, 2000).

To achieve this aim, Water Aid have designed a tool which involves the user in making decisions regarding certain drought issues in one of three countries, Ethiopia, Nepal and Ghana. Upon selection of the country of interest, the user is provided with background information regarding the problems faced by villagers (specifically children of a similar age to those the tool targets) dwelling in the area, which also works to set the scene for the tool. It is here that information is also provided regarding the work carried out by Water Aid.

The user is able to interact with the game from this point onwards, by reading the story and deciding on the optimum decisions at each stage. The emphasis is on the sequence of correct decisions made and if the user selects the wrong decision, an explanation is available. However, the user may only get five answers incorrect (represented as losing a bucket of water every time). Failure to save buckets results in 'game over'. During the latter stages of the Water Aid game, the emphasis changes from that of drought to community participation, represented in Figure 3.5.

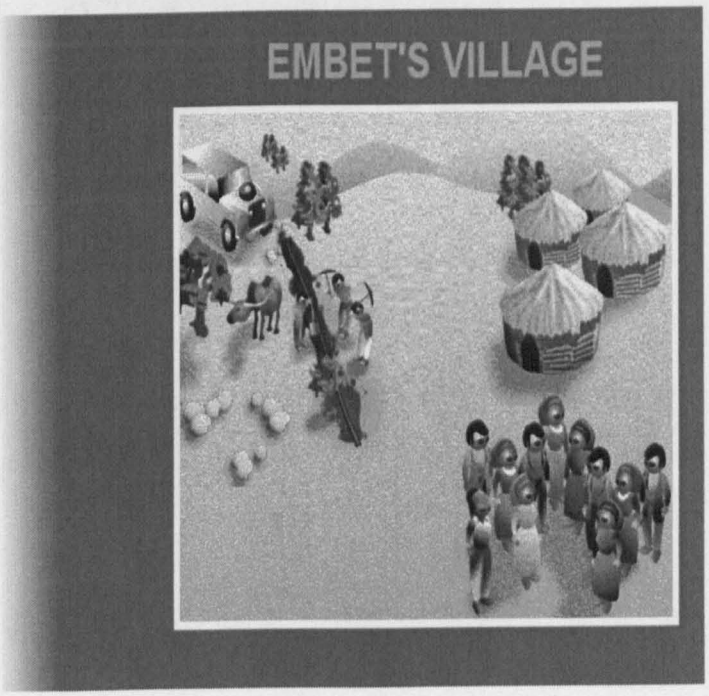

Figure 3.5 Screen shot of The Water Aid Game (Water Aid, 2000)

Upon game completion, the user is issued with a printable certificate and has the option of further investigating sanitation and hygiene education, by clicking on certain links and viewing photographs of real life projects.

Unlike the other tools, as well as focussing on drought related issues, the Water Aid game requires the user to consider the benefits of community participation and decision making. This is the only tool (of the four selected) which incorporates both educational issues and community participation promotion.

3.3.5 Summary

In summary, the Riverside Explorer (Environment Agency, 2000), Ecopod (2002), the Personal Barometer (2004) and the Water Aid Game (2000) were selected as the four ICT tools to be evaluated because they satisfied the selection criteria. The stipulations were that they were all created in the UK, were designed primarily for use by school students (with the exception of the Personal Barometer), but could be used by any interested party. A summary table of the characteristics of the selected tools is presented in Table 3.1. Such characteristics include intended audience, deployment context, date of publication, delivery mode, media, navigation and user control.

Table 3.1 Summary table of platforms selected

Platforms	Characteristics							
	Intended audience age range	**Deployment context**	**Year of release**	**Delivery mode (Web, PC)**	**Media (Stills, movies, sound)**	**Navigation**	**User control (functionality)**	**Help functions available**
Riverside explorer (Environment Agency)	10-15 but available to all	Class room	2000	PC	Stills, sound (narration), movies, animation	Branching	Full control	Installation instructions, Glossary and Teachers notes
Ecopod (Environment Agency)	11-15 but available to all	Classroom / home	2001	Web, PC	Animation, sounds	Linear	Controlled by game	Limited
Personal Barometer (Cranfield University)	Available to all	Classroom/ home/ Participatory processes	2004	PC	Stills	Branching	Full Control	Full help section and calculation assumptions
Water aid game (Water Aid)	11-14 but available to all	Classroom / home	2000	Web	Animation	Linear	Controlled by game	Yes how to play and how it works

3.4 Respondent Selection

An activity was carried out in order to determine which types of respondents should take part in the evaluation sessions. The first group identified were the developers of the selected ICT tools, as it was desirable to determine which strategic objectives the developers considered when designing their prospective tools. The target audience for the ICT tools were primarily school students, so local schools were contacted and time arranged to carry out evaluation sessions. The tools are also accessible to and usable by adults; consequently postgraduate students were included as an additional response group. To conclude the study, a small group of experts in the field of software design, evaluation and education were invited to take part in evaluation sessions. This activity was carried out to enable a comparison between the strategic objectives considered by the developers during tool design and those objectives considered to be promoted by the tools as selected by the experts. Table 3.2 shows the various evaluation groups and the corresponding evaluation activities that were adopted.

Table 3.2 Respondents and the evaluation activities that they were engaged in

Respondent group	Evaluation activity	Reference
Developers	Tick box self response sheet	Appendix 1
School students Postgraduate students	Pre and post interaction questionnaires and scenario discussion	Appendix 2
Experts	Likert scale based on self complete questionnaire	Appendix 3

3.4.1 Developers

The first steps towards respondent selection began with the selection of the tools used because this in part determined the developers who were to take part in the evaluation investigation. The developers of the selected ICT tools were contacted and asked to participate in an evaluation activity. They were emailed and asked whether they considered any of the strategic objectives when they designed their prospective tools (See Appendix I). These strategic objectives were trust, education, justice, inclusion, commitment and openness.

3.4.2 School Students

As most of the pre-existing tools short listed in Section 3.5 were designed for students aged between 10-16 years, it was necessary to involve that target audience in the testing of the platforms. At the schools, each evaluation group contained four respondents to allow a discussion to take place, thereby supporting the evaluation of the justice and openness strategic objectives. Each group tested only one ICT tool and therefore at each of the four schools each tool was tested once. A total of four evaluations were carried out at each school visited.

To be able to carry out the evaluation with student respondents contact was made with different secondary schools in the Buckinghamshire and Bedfordshire area. A template for a letter of invitation to participate was drafted and schools in the local area were invited to take part. This was an entirely random process, the only stipulation being that the schools contacted catered for children between 10-16, so the majority were upper schools. During this time it became apparent that many schools were busy with exams and other internal activities, so once contact was made, and an interest expressed, the sessions usually took place very quickly over subsequent weeks. Once the evaluation sessions were completed a letter of gratitude was sent to the head teachers of the participating schools. The teachers who facilitated the evaluation sessions were also thanked.

The evaluation sessions held at the schools took place at times that were most convenient for the teachers involved. For School A, a session was conducted every Friday over four weeks. These sessions were conducted during the afternoon once the school day was finished. Similarly School B opted for a session a week over four weeks, but the sessions were conducted over the lunch hour, respondents therefore giving up their free time to volunteer to help. A more intense set of evaluation sessions were held at School C, where two sessions were conducted during lesson time over two consecutive mornings. Finally School D facilitated the evaluation by organising to have four sessions over four weeks, one session taking place each week. At Schools C and D the teachers opted to allow students to carry out the session during lessons, thus incorporating ICT use into their teaching activities.

3.4.3 Postgraduate Respondents

As well as including both the developers and target audience in the evaluations, a further respondent group was involved. Postgraduates students from Cranfield University were asked to volunteer to take part in the evaluation work.

The respondents based at Cranfield University were contacted using the university intranet messaging facility. Once initial contact was made each respondent was asked at what time of day they would generally be available to take part in an evaluation session. This was either mornings, at lunch time, in the afternoon, or after work. A respondent database was constructed so that respondents could be put into groups of four according to which time was most convenient for them to participate. The respondents were then invited to a session at an appropriate time and following the evaluation an e-mail of thanks was sent to every respondent.

The evaluation sessions were held in a room specially designed to facilitate the evaluation activities. Four computers were set up with the necessary specifications to enable use of all tools. It was important that an area for questionnaire completion and scenario discussion was also available. A plan of the evaluation suite can viewed in Figure 3.6. Figure 3.7 shows a photograph of a respondent interacting with the Personal Barometer platform.

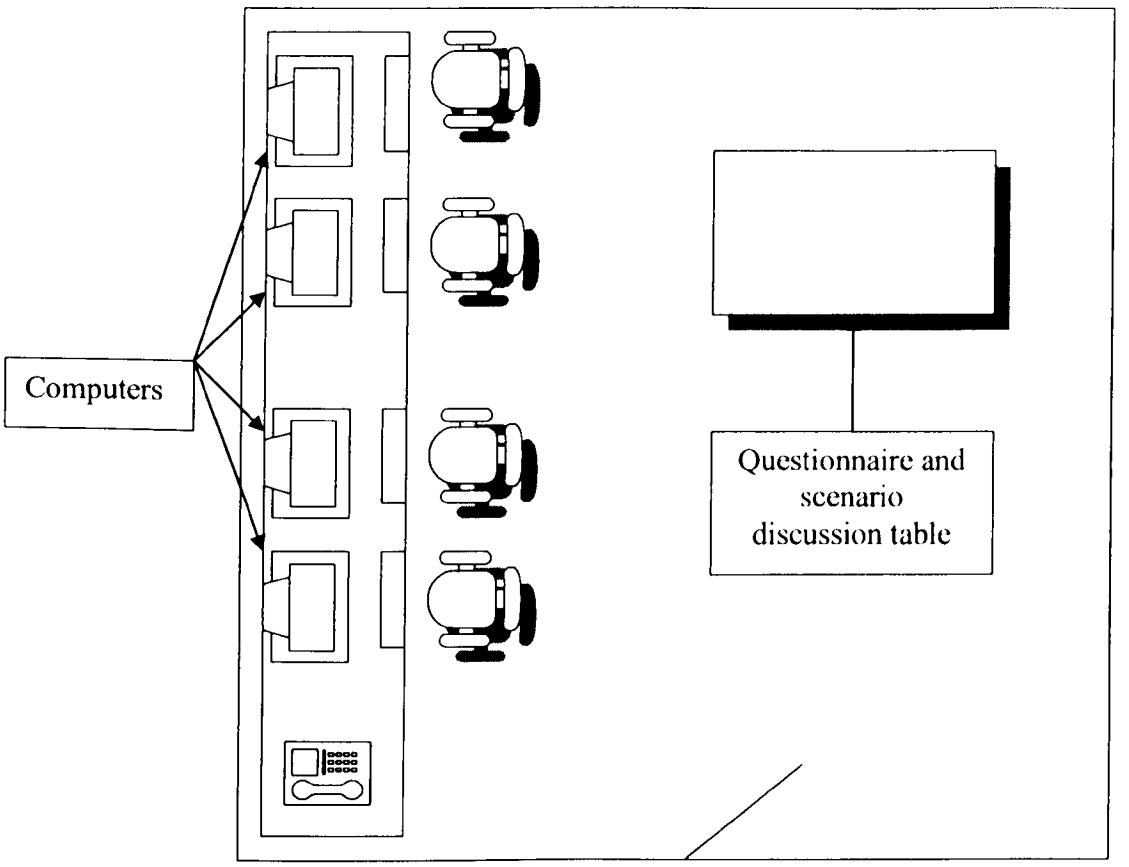

Figure 3.6 ICT tool evaluation room configuration

Both time and monetary constraints limited the number of evaluation sessions that took place and therefore the number of participants that took part in the investigation.

The length of time it took to plan the sessions reduced the amount of time available to actually carry out the sessions. A financial reward was also offered to postgraduate volunteers willing to take part in the session. Budgetary constraints limited the number of respondents who could take part.

The user evaluation session schedule was as follows:

- Completion of a self complete questionnaire.
- Discussion of a platform specific pre interaction scenario (to be taped).
- Interaction with the tool
- Completion of a post interaction self complete questionnaire (Same wording as pre interaction questionnaire).
- The discussion of a platform specific post interaction scenario (to be taped).

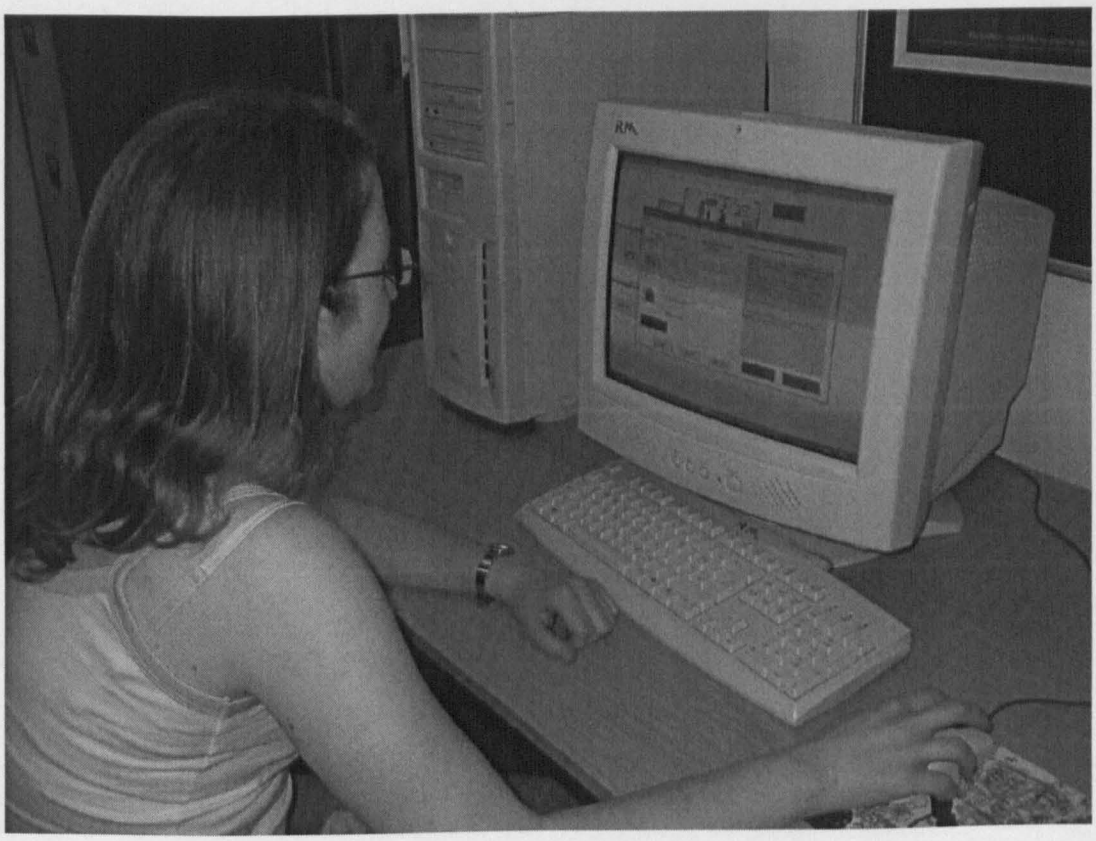

Figure 3.7 Respondent interacting with the Personal Barometer

3.4.4 Expert Respondents

Following evaluation work involving the developers, school and postgraduate student respondents a final activity was carried out involving expert evaluators. A group of four individuals were selected for their expertise in the fields of environmental education, expertise in ICT evaluation or educational software design. These evaluation sessions

were conducted both at the Cranfield University campus and off site. The experts were given a similar questionnaire to that of the developers, where they were asked to judge whether each of the four tools (The Riverside Explorer, Ecopod, The Personal Barometer and Water Aid) promoted the six strategic objectives selected (trust, education, justice, inclusion, commitment and openness). These one-on-one sessions constituted the final element of the evaluation activity.

During the evaluation sessions involving the experts, the respondents were first asked to read the definitions of the strategic objectives to be judged. They were then given as much time as they required to interacted with each of the ICT tools. After interacting with each tool, the experts were asked to judge the degree to which the tool promoted the strategic objectives listed. The final activity required the experts to make a direct comparison between all four tools in terms of the promotion of all of the strategic objectives.

3.4.5 Computer requirements

Most of the participating schools opted to carry out the evaluation sessions in their ICT suites and as described above, the postgraduate evaluations were carried out in a specially designed computer room where it was necessary that four computers be available with internet access as the Water Aid Game was only available online. The Ecopod platform was originally also only available online, but was then removed during an update of the Environment Agency webpage. However, when contacted the Environment Agency kindly sent CD-ROM versions of the tool. The Riverside Explorer was disseminated in the form of a CD-ROM, so therefore the computers required CD-ROM drives. In School D no CD-ROM drives were available, so platforms were installed onto the school's network. The minimum requirements to run the Riverside Explorer were a Pentium 266 processor or above with 32mb RAM and MS Windows 95. It was also essential that the computers had a Macromedia Shockwave plug-in, but this was easily downloadable once administration rights were granted.

The evaluation sessions in School C were carried out using laptops. The requirements were exactly the same as mentioned previously and problems of internet connections were solved through use of the schools wireless intranet.

3.4.6 Ethical considerations

Working with children required possession of an enhanced CRB (Criminal Records Bureau) certificate and this was obtained prior to the investigation work. To ensure a proper standard was followed during all the evaluation sessions, the ethical guidelines set out by the British Psychological Society in their 'Code of Conduct', ethical principles and guidelines document (British Psychological Society, 2005) were adhered to. Anonymity was respected and all respondents were informed that they were able to leave the session whenever they wished. Finally before the scenario session was taped, the respondents were all asked permission to record their deliberations.

3.4.7 Eliminating bias

Bias was a constant consideration during the design stages of this investigation. To reduce unfairness and bias during the evaluation work, the decision was made that respondents would be randomly selected and must have volunteered to take part in the evaluation work themselves. So for example, school students were not allowed to take part in the evaluation if they were just present because they had received a detention as punishment. Teachers who facilitated the evaluation sessions were instructed to randomly select school students who were of mixed ability and mixed gender, therefore ensuring the limitation of bias. It was also important that the respondent groups were made up of volunteers of the same age as it was felt that a mixture of ages could cause some strain on the discussions during the scenario. Therefore school student evaluation groups were made up of individuals from the same year group.

Another consideration was the number of occasions respondents were allowed to take part in the evaluation sessions. Repeated sessions with different tools could cause the respondents to compare the ICT platforms selected, therefore taking the emphasis of the exercise away from strategic objective promotion and focussing on comparisons

between existing tools. A strict rule was put in place to only allow volunteers to take part in the investigation once, so requests to take part in a second session were refused. Finally the exact same wording was used on both the postgraduate and school student questionnaires to ensure that all respondents would see the same questions, even though it was probable that respondents would view the questions differently from each other.

3.5 Experimental Design and organisation

3.5.1 Options to Support Evaluation

As little experience was possessed in the field of evaluation on the part of the author, advice from different sources was sought. These included the use of various evaluation texts such as Sniederman and Plaisant's (2005) text on ICT evaluation methods and Harvey's evaluation cookbook (1998). In terms of social research methods, texts by Robson (2002), Schutt (1996) and Bouma and Atkinson (1995) provided much guidance. Further to this, academics in the field of evaluation provided some valuable advice. The formulation of clear objectives for the study also aided the methodology selection process. In this section of the thesis a discussion of the available methodologies which could potentially have been used is presented, as well as the reasons why some were not utilised. From literature, a number of candidate approaches were available for selection, including:

- Questionnaires and surveys
- Likert Scales
- Pre and post testing
- Discussion groups
- Focus groups
- Supplemental observation
- Split Screen Video
- System log data
- Confidence logs

- Concept maps

In their social science research text Bouma and Atkinson (1995) identified the value of asking respondents questions in a face to face situation. In this thesis investigation, the evaluation sessions involving the user groups (the school students and postgraduate students) utilised both a questionnaire and discussion session. Schutt (1996) identified the different ways in which questionnaires can be administered, for example by post, completed by groups of people during a specified time, over the phone, or face to face with an interviewer. Table 3.3 summarises the way in which these methods are conducted.

Table 3.3 Methodology options for the deployment of surveys (Schutt 1996)

Method	Administration	Setting	Structure
Mailed survey	Self	Individual	Mostly structured
Group survey	Self	Group	Structured
Phone survey	Professional	Individual	Structured
In-person interview	Professional	Individual	Structured or Unstructured

In the case of this thesis investigation, a group type questionnaire approach was selected. This was because there was no other way that this could be completed because a discussion was required later on in the evaluation session. The way in which questions are phrased can differ in both a questionnaire and interview; these include open and closed questions and questions which require the respondents to select an answer from a scale (Likert type response). The advantages and disadvantages to utilising a questionnaire type method are outlined in Table 3.4.

Table 3.4 The advantages and disadvantages of using questionnaires.

Advantages	Disadvantages
Responses are gathered in a standardised way therefore questionnaires are more objective	Questionnaires usually occur after the event, therefore respondents may forget the important points
A fast method of collection	Misinterpretation may occur amongst respondents.
A large number of responses can be gained	Open-ended questions take a long time to process.
	Many get superficial answers from respondents who don't consider the question carefully
	Respondents may give answers that they think the evaluator wants to see or perceived 'correct' answers, rather their true feelings or opinions.
	Certain questions maybe missed out, or avoided because respondents don't want to complete them

The discussion conducted in the evaluation session was designed to uncover the promotion of certain strategic objectives, before and following interaction with the ICT tool being tested, but it also provided an opportunity to ask the respondents what they thought of the tool that they had interacted with. This was therefore an example of an unstructured interview.

Finally, Likert scales were used in some questions. Likert scales were developed by Likert in the 1930's and provide a summated rating in response to a question. This however is only one benefit to using Likert scales, as it was identified by Robson (2002) that respondents often enjoy answering questions using a Likert Scale, they often find it interesting, which could possibly lead them to giving the question more consideration. These can be used whether a questionnaire or interview type approach is being used.

The use of pre and post interaction questionnaires was to enable analysis of user responses both before interaction with the tool and after in order to determine the amount of influence the tool had on the user in terms of specific strategic objectives.

This also served as a gauge, to show the degree of change in respondent opinions across all groups. The only way to explore certain strategic objectives such as openness and justice was to conduct the evaluations with small groups to allow a short discussion to take place. This ruled out the possibility of utilising the administered questionnaire approach.

Mixtures of both open and closed questions were used and Likert scales (Foddy, 1993; Trochim, 2002) were adopted. Many researchers (Harvey, 1998, Robson, 2002) have identified the benefits of taping evaluation discussions as it allows an in-depth analysis. Therefore the discussions were taped and transcribed following the evaluation sessions. The respondents were asked not to discuss their opinions with other members of the group in an attempt to limit cross-respondent influence.

3.5.1.1 Focus Groups

One example of a technique considered but ultimately decided against was the focus group. Focus groups originated in the 1920's when it was discovered by researchers that many consumer decisions were made in a social, group context (Robson (2002). Later in the 1930's sociologists and psychologists developed these techniques further when they became dissatisfied with some of the more traditional survey methods. They were also used during World War II by the military to investigate morale (Schutt, 1996).

Focus groups are defined by Shutt (1996) as unstructured group interviews in which the focus group leader actively encourages a discussion among participants. These usually involve 7-10 people, who are selected to be homogenous and do not know each other. The advantages and disadvantages to Focus Groups as a social research method are summarised in Table 3.5

Table 3.5 The advantages and disadvantages of Focus Groups

Advantages	Disadvantages
• Amount and range of data • Natural controls on data Group dynamics help focus on important topics • Participants enjoy it • Method is inexpensive and flexible • Participants empowered and are able to comment in their own words • Participants usually reluctant to contribute are more likely to be involved • People who cannot either read or write are not discriminated against • Facilitation can help discussion of taboo subjects	• Number of questions covered is limited • Facilitating a group needs expertise • Interview process must be well managed • May get conflicts and power struggles between participants • Confidentiality may be a problem • Results cannot be generalised • Live and immediate nature of the interaction could lead research to place greater faith in the findings than are actually warranted

Use of a focus group could have been useful to determine the focus for the thesis, or for identifying key issues in the field of educational ICT tool evaluation. However, such a process was not needed as the literature review provided such a focus. The main advantage of a focus group as outlined by Jen Harvey (1998) is the fact that a large amount of information can be obtained on a certain topic within a short space of time, the disadvantage being that this is conducted in a deliberate and 'unnatural' setting. This disadvantage was the same for the way in which the evaluation sessions were actually carried out, by putting respondents in a room and asking them to respond to a questionnaire (which amongst other things tested their knowledge), interact with an ICT tool which was new to them and then ask them to discuss an issue with a group of strangers was not a natural setting. However this method was not used and any bias from the procedure selected was considered and is reflected upon later in the thesis.

3.5.1.2 Supplemental Observation

During the evaluation sessions which were conducted as part of this thesis investigation, although information was obtained through the respondents completing questionnaires and through the recording and transcribing of the scenario discussions, the supplemental observation technique was not utilised. This was because supplemental observation is

(as outlined by Harvey (1998) a process whereby the evaluator either directly or indirectly observes users in a group interacting with an ICT tool, specifically how they make use of the tool. The evaluator using this approach should carefully consider whether they should be active or passive and also consider whether they should interact with the users, or whether this would be too intrusive. By using this method, the evaluator can focus the session on a number of issues, for example seeing how the respondents interact with a specific ICT tool, looking at the path the respondents take through the tool and where they are experiencing difficulties. Both Schutt (1996) and Robson (2002) identified the advantages and disadvantages to practising the observation technique and these are summarised in Table 3.6.

Table 3.6 The advantages and disadvantages to supplemental observation (Schutt (1996) and Robson (2002)

Advantages	Disadvantages
• Good Recall • Researcher watches, rather than asks	• Observer would not see and hear everything. • Answers are filtered by researchers own senses and objectives • Presence of observer may cause people to act differently • Discrepancies between what people say and what they actually do • Researcher never sure if the behaviour observed is identical or representative to real life

Observation was not considered to add any benefit to the process and outcomes under consideration in this thesis project, as questionnaires and scenario discussions were used, and respondents were asked in the latter (in the post scenario discussion) what their opinions were of the tool that they had just used. By adopting the Supplemental Observation technique a number of problems would have presented themselves, such as the need to employ other facilitators to observe each respondent, or the use of computer programs to monitor each respondent's route through the tool. It was felt that this method and the results obtained would be provide additional, but not useful information to the thesis project, as the promotion of strategic objectives was tested through the use of questionnaires. Viewing the path that the respondents were taking through the tool

would not help with the thesis objectives, unless perhaps a large amount of experience in the use of supplemental observation was possessed.

3.5.1.3 Split Screen Video

The use of split screen video has emerged as a research tool since the 1980's. This technique is beneficial if the evaluator wishes to concentrate on human computer interface elements of an ICT tool and test usability, or wish to seek the views of the respondent in terms of their perception of the software as a learning tool. (Shneiderman and Plaisant, 2005) To do this, the evaluator sets up a camera which focuses on the respondents' upper body in one half of the screen, and on the computer screen in the other half. This way the investigator can record the respondent's use of the tool and their face and hand movements. One disadvantage to using this technique is that the respondents involved in the evaluation may get nervous about being filmed and so may act differently compared to if they were not filmed.

Taking this into account, the work in this thesis focussed on uncovering the promotion of strategic objectives by certain tools, rather than looking at issues of usability. As well as this technique being wholly inappropriate to the project's objectives, there was a lack of experience on the part of the user to read body language and to both observe and draw conclusions from such an experiment. Therefore split screen video was not used.

3.5.1.4 System Log Data

This technique works by recording the exact way in which a user interacts with an ICT tools. Activity is recorded using a bespoke program, designed according to the research to be conducted. Types of activity that can be recorded includes menu calls, mouse clicks, the time spent on a certain page or task, or the frequency with which a certain object or icon is clicked upon (Shneiderman and Plaisant, 2005). Like the previously reviewed methods, system log data has uses specifically in usability testing and evaluation work involving navigation or tracking user preferences. The success of this method relies on careful planning and the smooth running of the evaluation session as no information can be collected after the event. The advantage of using this technique is that it is highly objective; producing a large amount of quantitative data, but the

downside is that it fails to answer why for example the user chooses a certain pathway through an ICT tool (Harvey, 1998). It is for these reasons that this method was not applied in this thesis. The focus of this thesis was to ascertain whether certain ICT tools promoted certain strategic objectives, not to determine usability or HCI interactions with the tool itself. Therefore rather than an objective approach, subjective methods were utilised.

3.5.1.5 Confidence Logs

Confidence logs are an example of a technique which could have been used in order to ascertain whether the respondents felt more confident answering the post interaction questionnaire, specifically the questions used to explore evidence of learning. In this thesis the learning questions in the survey were devised to simply ascertain whether the respondents knew the answers to the learning questions following tool use. A confidence log could have been included immediately following the learning questions to determine how confident the respondents were in the answers that they gave. This could have also worked to determine a link between learning and trust in the tool. To determine levels of trust confidence scales were used but these differ from confidence logs. This is because confidence scales were used to determine levels of confidence and hence trust in an ICT tool for example, and not the users own confidence in answering the questions. This method could be included in future work, however in this thesis project, it was deemed unnecessary since the aim of the work was to simply determine the promotion of learning, rather than to test respondent confidence. Also it was important to test strategic objective promotion independently of the other strategic objectives in order to avoid confusion.

3.5.1.6 Concept Maps

The final method that was considered for inclusion in this project was the use of concept maps. These are defined by Schutt (1996) as "A mental image that summarises a set of similar observation, feelings or ideas". This could have specifically been carried out during the final stages of the scoping study to determine the thoughts of the respondents involved in the study. However, as much was gained in the scoping study in terms of ideas and suggestions during the debrief session, it was felt that to further discuss what had happened in the session would only serve to cover old ground, and therefore it was

deemed unnecessary to use confidence maps at the end of the session. Finally, it would have been appropriate to employ the concept map technique if this investigation concentrated on the usability of ICT tools, and respondents could have been asked to draw a map to determine what their views of ICT tools were in terms of education. However, for the objectives of this thesis, using concept maps would have been a waste of time.

This section of the thesis has provided an in-depth discussion as to why certain enquiry techniques were selected over others. In order to answer the thesis questions in the most appropriate way, a pre and post interaction questionnaire was devised as well as a pre and post scenario discussion. A pre and post questionnaire was selected as a method of testing the promotion of strategic objectives. It was important to uncover existing respondent knowledge before they interacted with the ICT tool, so both the level of learning and influence of the tool could be discovered in the responses to the post questionnaire. This enabled the quantification of the impact that the tool had on the user in terms of strategic objective promotion. Finally a pre and post scenario discussion was used in this thesis investigation. This was to determine whether the educational ICT tools that the respondents used influenced them in thinking about real life situations. It also worked to discover the promotion of justice in the ICT tools selected for evaluation. Finally the respondents were asked their views of the ICT tools themselves. The advantage to using a discussion process was that a lot of data could be recorded and later transcribed that could be matched up later with the results of the questionnaire section of the evaluation. Therefore pre and post questionnaires and scenario discussions were determined to be the best methods by which the promotion of the six strategic objectives by the selected ICT tools.

3.5.2 How the respondent evaluation was conducted

The way in which the promotion of each strategic objective by the ICT tools was identified is described in the following section.

3.5.2.1 Learning

Learning was tested by asking respondents three questions both before and after tool interaction and assessing their ability to answer the questions correctly following use of the tool. The information required to answer the questions was contained in the screens which users were asked to review (See Appendix II, questions 1-3). An increase in the number of correct responses therefore implied that an increase in knowledge had resulted from use of the tool which was a good indicator that learning had taken place. In summary this method determined whether learning improvement had taken place, but also uncovered incidences where no change in learning occurred or even deterioration in understanding had taken place.

3.5.2.2 Trust

It will be remembered from Section 2.5.2.6 that three different types of trust were to be evaluated. Consequently, three elements of the evaluation session relate to this strategic objective. Before interacting with the tool, respondents were asked whether they were familiar with the organisation which had developed the platform and, if so, to explain in their own words what they thought it was responsible for. Subsequent questions focussed on the respondent's confidence in decisions made on their behalf by the organisation and also in the level of confidence that the user had in the information presented in the ICT tool created by the same institution. These were determined using confidence scales (See Appendix II, questions 6 and 7). After interaction with the ICT tool had taken place, and to determine the changing opinions of the respondent, they were asked to rank their confidence in decisions made by the organisation and the confidence they had in the material presented in the tool. When asked to reveal their opinions in terms of confidence in the tool and organisation the respondents were again

asked to select a number from a confidence scale, spanning from no confidence to very confident. A 'no opinion' option was also available for selection.

Finally, trust in the decisions made by the respondents during the scenario discussion section were determined using a confidence scale, where the respondents were required to select a number depending on how confident they were about their final decision (See Appendix II, question 17). They were required to do this both before and after tool interaction. To determine the promotion of the different types of trust, pre and post interaction questionnaire results were compared to determine whether the tool had promoted an increase in trust, caused no change, or had resulted in a decrease in trust.

3.5.2.3 Motivation

Ascertaining whether respondents felt more motivated to adopt an environmentally responsible lifestyle after using the selected tools was effected by asking the respondents whether they would help solve a water related environmental problem influencing their local area. This question was asked both before and after interaction with the ICT tools to gauge whether the platforms had instigated a change of opinion or intention. Motivation was gauged to determine whether there was an increase, no change or decrease in this strategic objective following use of the tool (See Appendix II, question 8).

3.5.2.4 Inclusion

To determine the promotion of inclusion, respondents were asked an environmentally relevant question specific to the ICT tool being evaluated; for example whether they thought wildlife habitat destruction was a problem that they should be concerned with (relevant to The Riverside Explorer Platform). They were also required to provide a short answer as to why they were either concerned, or not with the issue. Again, the respondents where asked to answer this question both before and following tool use so that an increase, decrease or no change in feelings of inclusion could be detected (See Appendix II, question 14).

3.5.2.5 *Justice*

It was recognised that testing for the promotion of justice in a process required observation and recording of group interaction. Interviewing one individual at a time would not have been suitable as a way of determining whether the tool instilled justice. It was therefore proposed that a scenario session involving the individuals was the best option, where a decision context could be created centred on an environmental issue. The discussion was taped so that the deliberations could be transcribed and analysed. Evidence of justice was uncovered through analysis of the evaluation session transcripts to determine promotion of this strategic objective. In the transcripts, where all of the respondents within a group gave their opinions, which led to a decision being made, the outcome was considered to be a just one. This shows that every individual in the group had an opportunity to give their opinions during the scenario discussion, and did so.

3.5.2.6 *Openness*

The promotion of openness was also tested during the scenario discussion session. This served to gauge how fair each respondent thought the others were in terms of the interaction between them whilst discussing possible solutions to the scenario problems. After the respondents had discussed the scenario and a decision was reached by each member of the group, they were asked to rate the other participants in terms of openness using a scale before and after tool use. By asking the respondents to complete this both before and following tool use enabled the determination of openness promotion following tool use (See Appendix II, question 18).

3.5.3 *Comments on the strategic objectives*

The shortlist of strategic objectives above were used specifically for the evaluations involving the user groups. However, during the developer and expert group evaluations, education was used in the place of learning, and commitment in the place of motivation. This was because the short list of strategic objectives used in the user evaluations was not finalised until after the developer evaluations had taken place. After consideration as to the level of complexity that the term 'education' possessed, learning was considered more appropriate for the user evaluations. Education for example, implies both the teaching and learning, or the exchange of information from one individual to another.

Rather than focussing on the teaching aspect of ICT tools, or indeed the exchange between the pedagogue and the learner, a user centred approach was adopted, where the degree to which learning was promoted by certain ICT tools was analysed. Initially commitment was on the shortlist, but this was subsequently changed to motivation. Evaluating ICT tools in terms of promotion of commitment would have been problematic using the evaluation session / questionnaire approach as an individual's commitment would have been tested over a period of time. The respondent groups, and the strategic objectives tested by each are shown in Table 3.7.

Table 3.7 Shortlist of strategic objectives tested according to response group.

	Respondent Group		
Strategic Objective	**Developers**	**Users**	**Experts**
Learning	×	✓	×
Education	✓	×	✓
Trust	✓	✓	✓
Inclusion	✓	✓	✓
Motivation	×	✓	×
Commitment	✓	×	✓ (Motivation)
Openness	✓	✓	✓

However, to enable a rough comparison in the results and discussion chapters, education is compared with learning and motivation compared with commitment.

3.6 Data Analysis Techniques and Methods

As noted previously, the evaluation sessions involving the user groups were designed in such a way as to attempt to discover which of the ICT tools selected promoted certain strategic objectives. This Section details the data management and analysis approaches adopted for the study.

3.6.1 Data management

The efficient collection and storage of data from all questionnaires was vital in order to keep track of the obtained results. A database was compiled of all of the responses from the questionnaires; the most involved being the questionnaire developed for completion

by the school and postgraduate respondents. Once an evaluation session was completed, the results from the questionnaires were inputted into SPSS 11.0 (SPSS Inc, 2002) for storage and later analysis.

3.6.2 Metrics for each strategic objective

Where 'learning' was tested, the user's answers to the questions both before and after tool use were compared, to see if an improvement had been made following tool use. 'Trust' was evaluated by determining whether there was an increase in the three types of trust (trust in the institution, trust in the content of the tool and trust in decisions made by the user following tool use). The strategic objectives, 'motivation' and 'inclusion' were analysed by determining the number of respondents whose motivation and feelings of inclusion were heightened following use of the tool. In order to analyse for 'justice' a discussion was facilitated both before and following tool interaction, where the respondent groups were asked to make a decision regarding a water environmental issue, which was specific to the computer tool interacted with. Evidence of 'justice' was determined through careful analysis of the interview transcripts.

Examples of the questionnaires sent to the tool developers, used in the school and postgraduate evaluation sessions and during the expert evaluations can be found in Appendices 1, 2 and 3 respectively.

As a summary, Table 3.8 shows how each strategic objective was analysed and also shows the criteria applied to test strategic objective promotion in each case.

Table 3.8 Strategic objective metric

Strategic objectives	Measure	Question number	Criteria for strategic objective promotion
Learning	Pre and post questionnaire	1-3	More questions answered correctly following tool use indicates learning.
Trust in the institution	Pre and post questionnaire	4-6	Higher score on Liket scale following tool use indicates increase in trust.
Trust in the information contained within the tool	Pre and post questionnaire	7	Higher score on Liket scale following tool use indicates increase in trust.
Trust in decisions made following tool use	Pre and post questionnaire	17	Higher score on Liket scale following tool use indicates increase in trust.
Motivation	Pre and post questionnaire	8-13	-Positive response to question following tool use (if the pre interactive response was negative) indicates an increase in motivation.
Inclusion	Pre and post questionnaire	14-16	Positive response to question following tool use if the pre interactive response was negative) indicates an increase in inclusion
Justice	Pre and post scenario discussion	Disc.	Scenario discussions were recorded and the transcriptions analysed for evidence of justice
Openness	Fairness scale	18	Openness was promoted by the tool if fairness scale increased.

3.6.3 Comments on Methodology

Those schools invited to take part in the evaluation sessions took a while to respond. All located in the Bedfordshire area, 28 schools were contacted and four schools responded. Of the 28 schools only one sent a letter apologising for not being able to take part in the evaluation session.

One of the main difficulties encountered with the evaluation sessions was ensuring that the correct number of postgraduate respondents attended each evaluation session. Even though respondents were asked to specify times that were most convenient for them to attend evaluation sessions, some failed to turn up. Although this did not affect the questionnaire and interaction sections of the evaluation sessions, it could have implications on the scenario discussion section. Therefore, a session was still run if three respondents attended, but was cancelled if only two respondents were present because it was doubtful that a reasonable discussion would be achieved.

Another problem involved the transcribing of the discussions. Although the discussions were taped, transcribing had to take place in a short time following the evaluation because it was often difficult to remember who had said what, or to distinguish between the respondents. This was partly overcome by the immediate transcription of the discussion, but a representation of the table layout, which marked where respondents were seated, aided this process.

Fortunately most of the problems were easily resolved. Enough of the schools invited agreed to take part in the investigation, and ample postgraduate sessions were run to gain meaningful results. The difficulty of recognising respondent voices was overcome by drawing a seating plan to determine where each respondent was sitting, as well as transcribing the discussion in as short a time as possible.

4 Results

4.1 Introduction

The results from all three evaluation activities will be presented in this chapter which comprises three sections; Section 4.2 reports the results from the questionnaires sent to the developers, Section 4.3 presents the results from the evaluation, conducted with the school children and postgraduate respondents; finally, the evaluation activities involving experts are presented in Section 4.4. A comparison of the experts' results with the developers' results is also presented Section 4.5. The aggregated results by platform and strategic objective are presented in Section 4.6 and in Section 4.7 a summary of the results is provided.

4.2 Results from the platform developers' evaluation

When presented with the list of strategic objectives, (Chapter 2, Section 2.5) the developers of the four evaluated tools were asked to determine which of the objectives had been consciously included as a design consideration when they developed their prospective tools. The results (Table 4.1) show that the Environment Agency (the developer of the Ecopod platform) considered all six strategic objectives. Cranfield University, the developers of the Personal Barometer, considered a total of four strategic objectives. When developing the Riverside Explorer, the Environment Agency claimed that they only considered one of the listed objectives (education). Finally, the developers of the Water Aid Game (Water Aid) stated that education was the sole objective considered during the design stages of their ICT tool. These results constitute a baseline of intended strategic objectives which will be compared with the user and expert evaluations in Sections 4.3 and 4.4.

Table 4.1 shows that across all tools, education (learning) was the most commonly targeted strategic objective, followed by inclusion, commitment (motivation) and openness. Trust and justice was considered the least by the developers during tool design.

Table 4.1 Strategic Objectives considered by all of the developers of the tools.

Strategic Objectives	Tools				Number of platforms seeking to promote the objective
	Riverside Explorer	Ecopod	Personal Barometer	Water Aid Game	
Trust	×	✓	×	×	1
Education (Learning)	✓	✓	✓	✓	4
Justice	×	✓	×	×	1
Inclusion	×	✓	✓	×	2
Commitment (motivation)	×	✓	✓	×	2
Openness	×	✓	✓	×	2
Total (for each tool)	1	6	4	1	

4.3 Results of the users' evaluation

A total of 105 respondents were involved in the evaluation activities over the course of 28 evaluation sessions. Of a total of 105 respondents, 60 of the participants were school students and 45 were postgraduate students. The evaluation process was identical for both groups. Sixteen evaluation sessions were carried out in local schools and twelve took place on the Cranfield University campus. The evaluation sessions conducted with school students, involved all four tools being tested, across all of the four schools visited. For the evaluations conducted on campus, each tool was tested during three sessions. The respondents were only allowed to take part in one evaluation session and therefore only ever interacted with one tool.

The results for the school and postgraduate respondent evaluations are presented by strategic objective. This is broken down into two parts, the first displays the strategic objective promotion across all tools, whilst the second shows the strategic objective promotion by each individual tool. By looking at the promotion of strategic objective across all tools, an overall indication of ICT tool performance can be gained, whilst the second results presentation format allows comparison between tools. However, due to the way in which the evaluation process was conducted using pre and post testing, the data had to be analysed and then manipulated in order to determine 'Normalised' values. Consideration of the normalised values is especially important when comparing the tools with each other in terms of strategic objective promotion. It would be misleading to say that one tool was better at promoting a particular strategic objective than another tool based on the absolute results because the potential for improvement for example varied between tools. The way in which the normalised data was calculated is explained in Section 4.3.1.

4.3.1 Calculating the normalised results

As described above, the testing of strategic objective promotion by each of the ICT tools involved a pre and post interaction questionnaire. This was used to measure the changing opinions of the respondents by taking a 'snap shot' of their opinions both before and following interaction with the tool. This approach reveals the number of

respondents who displayed an increase, no change or decrease in performance against the six strategic objectives. However, because not all the respondents were able to improve their score between the pre and post interaction evaluations, the overall population scores need to be placed in context. Improvement or deterioration in score could only be achieved by those respondents who did not score, respectively, the maximum or minimum score in response to the pre-interaction questionnaire. For example, a respondent who answered all the pre-interaction learning questions correctly would be unable to exhibit an improvement. Furthermore, when the learning strategic objective was tested, account had to be taken of the number of test questions that each respondent answered correctly before tool use (three pre and post questions were used to measure promotion of this strategic objective). The range of possibility spanned from each respondent getting no correct answers to three correct. The possible combinations for the questions related to the learning strategic objective of pre and post responses are shown in Table 4.2. The normalisation procedure is specific to each individual tool and produces one measure per tool, rather than creating a single normalised value across all tools.

Table 4.2 Possible pre and post response combinations for the learning strategic objective (IAC=Improvement in their ability to answer questions about the platforms content, NC= No change ability to answer questions about the platforms content, DAC= A deterioration in the ability to answer questions about the platforms content).

Pre- interaction question –number of correct responses	**Post – interaction question – number of correct responses**			
	0	1	2	3
0	NC	IAC	IAC	IAC
1	DAC	NC	IAC	IAC
2	DAC	DAC	NC	IAC
3	DAC	DAC	DAC	NC

If a respondent scored a maximum in the pre-interaction questionnaire, then a maximum score in the post-interaction questionnaire only allows the conclusion that there was no

deterioration in strategic objective achievement along the dimensions that we selected to be measured, i.e. the themes of the questions. When a respondent either achieved a maximum score both before and following tool interaction, or a minimum score both before and following tool use, this implies that there was no deterioration or no improvement respectively. There is no way of measuring an improvement if an individual scored a maximum in the pre-interaction session. This is not the same as their not being any improvement, there simply is no way of measuring it (the same goes for the minimum score) and therefore, this reveals a limitation of the scoring system and evaluation technique.

The same analysis technique was adopted with the trust, motivation, inclusion and openness strategic objectives although they involved fewer possible combinations. In the case of motivation, for example, each respondent could answer pre tool use that they would be motivated to help solve environmental issues or not and this is outlined in Table 4.3. It was possible for no change in motivation to take place, for example if they were motivated both before and following tool use, therefore showing that they were not influenced by the tool.

Table 4.3 Possible combinations for strategic objective 'motivation', where IM = increase in motivation, NC= No change in motivation and DM = Decrease in motivation.

Pre- interaction question – number of correct responses	**Post – interaction question – number of correct responses**	
	1	2
1	NC	DM
2	IM	NC

To calculate the normalised results, the following calculations were carried out. The normalised figures were generated by dividing the number of improvers by the number of respondents that could exhibit an improvement in their score from the pre-interaction results. The normalised number of respondents who did not improve or get worse following tool use was found by dividing the number of non-improvers (no change) by the total number of respondents. Finally the normalised number of deteriorators was found by dividing the number of deteriorators by the number of respondents who could have registered a deterioration in their score after the pre interaction questions. Tables 4.4 and 4.5 present examples of the normalised calculations involving the learning and motivation strategic objectives.

Table 4.4 Normalisation calculations for the learning strategic objective

Learning Category (x axis)	**calculation**
Improvers	Number of improvers / number of respondents who did not get all of the learning questions correct during pre interaction questions.
Non improvement / No change	Number of non improvers / all respondents
Deterioration	Number of deteriorators / number of respondents who did not get all of the questions wrong

In those figures that report the normalised data (e.g. Figure 4.1), the Y axis represents the absolute number of respondents in each category and the Z axis, the normalised numbers. Each respondent was classed as either an improver (Increase in their ability to answer questions about the platforms content), learning non improver (no change in their ability to answer questions about the platforms content) or a learning deteriorator (A decrease in the ability to answer questions about the platforms content) according to their responses to the pre and post questionnaires

Table 4.5 Normalisation calculations for the motivation strategic objectives.

Trust Category (x axis)	Normalisation calculation
Increase	Respondents who increased in motivation / number of respondent who would not help solve an environmental issue affecting their local area
No change	Number of no changes / all respondents
Decrease	Respondents who decrease in motivation/ number of respondents who did not get all the questions wrong

Section 4.3.2 focuses on the degree to which each strategic objective was promoted by each of the four tools. Each result is described in two stages; the results obtained from the school respondents are shown first, followed by those obtained from the postgraduate respondents.

It should be noted that a summation of the proportion of respondents who increased, exhibited no change or decreased in their ability to answer the learning questions or increased did not change or decreased in the case of the other strategic objectives would be expected equal one. However, on some occasions the summed normalised values are greater than one. This is because one individual could be counted towards more than one divisor, i.e. a respondent could be in the potential 'no change' and the potential 'improver' categories.

4.3.2 The degree to which the Strategic Objectives were promoted across all tools

The tables and figures in this section show the degree to which each strategic objective was promoted across all tools in the two respondent groups. For each strategic objective the results are reported as both absolute values and normalised values presented in brackets (). Table 4.6 shows the strategic objective promotion across all tools following the evaluation sessions involving the school respondents. Table 4.7 shows the same but for the postgraduate respondents. The tables present the data as both absolute numbers

and also normalised values. Also included in the tables are the numbers of individuals that could improve, the number that could not improve and the number who could not get worse. Of those that could not improve, the number of respondents who achieved the same score or deteriorated /decreased is shown. A special case is made for learning as it is the Strategic Objective revealed as the most considered by the developers in their evaluation and therefore will be presented in the form of bar charts as well as in Tables 4.6 and 4.7. Showing the results in the bar chart adds an extra dimension to the learning results, so the trend in absolute and normalised data can be demonstrated.

Table 4.6 School respondent results by strategic objective across all tools

Key

nc - no change

det - deterioration

dec - decrease

nr - no response

Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	33 (0.6)	19 (0.3)	8 (0.2)	58/60	2 [1 nc, 1 det]	42	18
TII	29 (0.5)	23 (0.4)	8 (0.1)	55/60	5 [4 nc, 1 dec]	59	1
TICT	34 (0.6)	19 (0.3)	7 (0.1)	53/60	7 [5 nc, 2 dec]	60	0
TID	25 (0.5)	27 (0.5)	8 (0.1)	46/60	14 [10 nc, 4 dec]	60	0
Motivation	6 (0.2)	53 (0.8)	1	25/60	35 [34 nc, 1 dec]	35	25
Inclusion	8 (0.5)	50 (0.8)	2	17/60	43 [41 nc, 2 dec]	44	16 (1 nr)

Table 4.7 Postgraduate respondent results strategic objective across all tools

Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number could improve	Number could not improve	Number who could get worse	Number could not get worse
Learning	22 (0.6)	18 (0.4)	5 (0.1)	36/45	9 [8 nc, 1 det]	41	4
TII	25 (0.6)	18 (0.4)	2	44/45	1 [1 nc]	43	2
TICT	26 (0.6)	16 (0.4)	3 (0.1)	43/45	2 [1 nc, 1 dec]	45	0
TID	21 (0.5)	14 (0.3)	10 (0.2)	39/45	6 [3 nc, 3 dec]	45	0
Motivation	2 (0.2)	42 (0.9)	1	9/45	36 [35 nc, 1dec]	36	9
Inclusion	2 (0.7)	42 (0.9)	1	3/45	42 [41 nc, 1dec]	42	3

Learning

The results for the learning strategic objective amongst school respondents are shown in Figure 4.1 and Table 4.6. A special case was made for the learning strategic objective as it was the strategic objective considered by all of the developers during the design of their ICT tools. Therefore the data is presented both in tables and graphically, the latter selected so that the trends of both the absolute and normalised data can be visualised.

Looking at the data, the majority of school respondents exhibited an improvement in learning after using their respective tools (33 pupils out of 60). The number of respondents showing no improvement was 19 out of the 60 pupils. Finally respondents who exhibited deterioration in their ability to answer questions relating to the content of the tool that they interacted with were in the minority; 8 showing a deterioration. Looking at the normalised data, of the respondents that could show an improvement, 0.6 actually did, 0.3 stayed the same and 0.2 displayed a learning deterioration.

The results involving the postgraduate respondents are similar to that of the school respondents. Figure 4.2 and Table 4.7 showed that for this group, the greatest proportion of postgraduates improved following use of the respective tools (22 out of 45). Compared with the group of postgraduates that improved, fewer exhibited no improvement (18 out of 45), whilst 5 postgraduates exhibited a deterioration in learning following tool use. In terms of the normalised data for the postgraduate group, a total of 8 individuals were unable to improve in terms of learning, having got all of the answers correct in the questions pertaining to learning in the pre interaction questionnaire. Therefore 0.6 showed a learning improvement, 0.4 exhibited no change and 0.1 exhibited a learning deterioration.

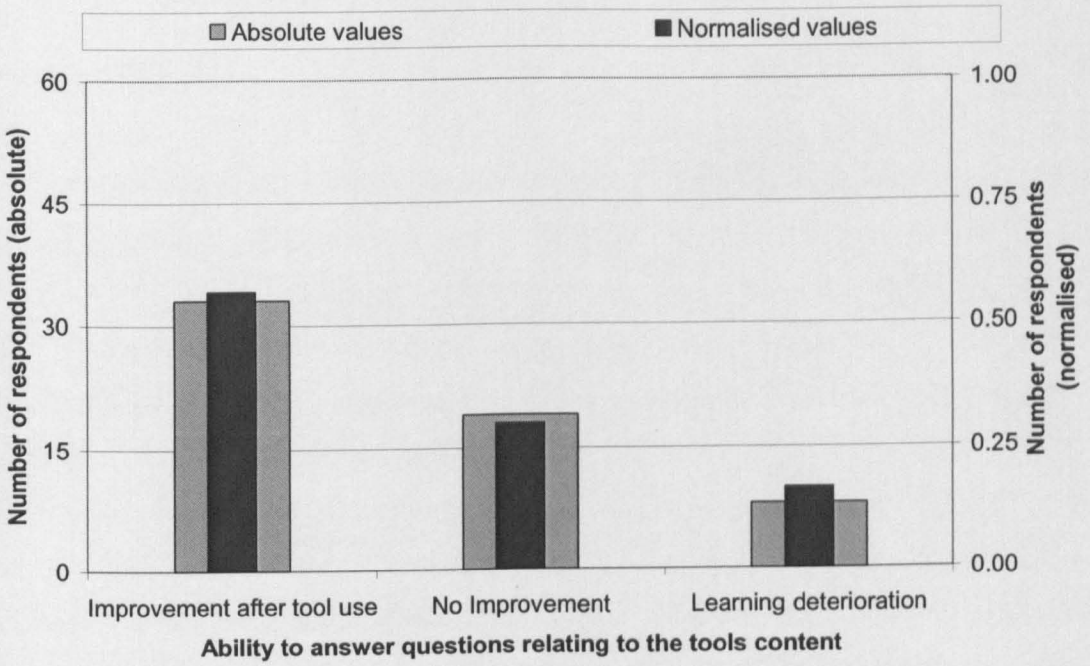

Figure 4.1 The ability of school respondents to answer questions relating to the tools content (Learning strategic objective).

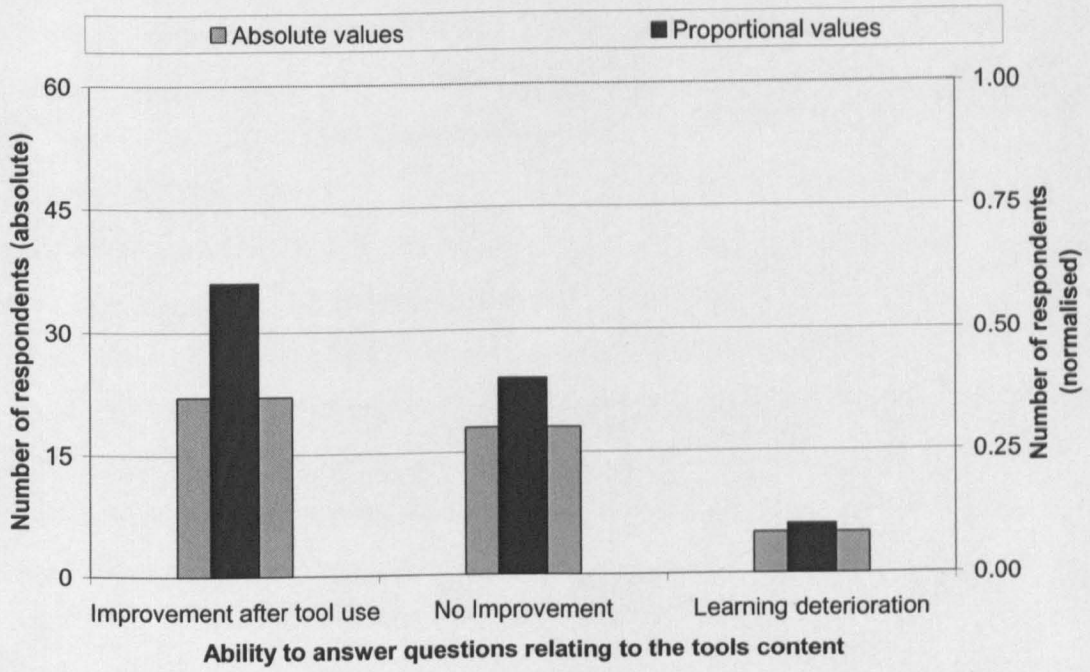

Figure 4.2 The ability of postgraduate respondents to answer questions relating to the tools content (Learning strategic objective).

Trust In Institution

The strategic objective, 'trust in the institution' (TII) focussed on those organisations that developed each of the tools. It was found that there was an increase in this form of trust after the respondents interacted with their respective tools, but to differing degrees when the evaluations involving the school and postgraduate respondents are compared. Table 4.6 shows that TII increased in the majority of school respondents after they interacted with their respective tools (29 out of 60 school respondents improving. A smaller proportion of school respondents were unaffected regarding trust issues (23 out of 60). The least common outcome of the evaluation was 'decrease in trust' which indicated that the use of the ICT tools had a negative impact on only a small proportion of the school respondents (8 out of 60). The results revealed that within the school respondent group, it was impossible for 5 of the individuals to register a score indicating an increase in trust, as they had indicated that they fully trusted the institution that created the tool in the pre interaction questionnaire. This fact is reflected in the normalised results; of the respondents that could improve 0.5 did, whilst 0.4 displayed no change and 0.1 exhibited a decrease in trust.

The trend of the postgraduate respondents was similar to the school respondents with regards to TII promotion, which is presented in Table 4.7. The greatest number of postgraduate respondents improved following use of their respective tools (25 out of 45) followed by the group that exhibited no change (18 out of 45). Only 2 out of the 45 postgraduates exhibited a decrease in trust following tool use (pro 0). When looking at the normalised data of the respondents that could improve 0.6 did, 0.4 showed no change and less than 0.1 showed a decrease in trust.

Trust in the tool

Trust in the computer tool (TICT), which focuses on the content of each tool is the second type of trust associated strategic objective to be presented in the results. It is inextricably linked to the TII strategic objective because respondents were asked if they would trust the content of the tool made by the organisation which developed each tool.

They then went on to interact with the tool in question. Again, the results from the evaluations involving the school respondents will be presented first. There was an increase in this form of trust in the majority of school student respondents following tool interaction, with 34 showing an increase in trust, (normalised value of 0.6) (Table 4.6). A smaller proportion of respondents, 19 out of 60 (normalised value 0.3), exhibited 'no change' in trust following use of their respective tools and the smallest category was the proportion of schools respondents who exhibited a decrease in this type of trust following tool interaction where 7 exhibited a decrease in trust (normalised value of 0.1). Following completion of the pre interaction questionnaire it was revealed that 7 school respondents were unable to record an increase in terms of this type of trust.

Once again, a similar trend was observed in the results of the postgraduate respondent interaction (Table 4.7) where 26 individuals (normalised value of 0.6) displayed an increase in trust, 16 (normalised value of 0.4) showed no change following use of the respective tools and 3 (normalised value of 0.1) showed a decrease in trust. In terms of the normalised data, 2 individuals could not increase in trust owing to their responses in the pre interaction questionnaire.

Trust in decisions made

The results of the strategic objective 'trust in decisions made following tool use' (TID) (Table 4.6), show that there was a slight difference to the trend of these results compared to trends of the previously reported strategic objectives. The greatest proportion of school respondents exhibited no change in TID (absolute 27, normalised value 0.5) whilst 25 (normalised value of 0.5) individuals displayed an increase in this type of trust. A group of 8 individuals exhibited a decrease in trust following use of their respective tools (normalised value of 0.1). These results indicate why it is important to consider the number of individuals that could not possibly increase TID owing to their responses in the pre interaction questionnaire. In this case, 14 school respondents could not increase in terms of trust demonstrating the importance of reporting the results as both absolute and normalised figures.

Differing from the results of the school respondents in terms of TID, the postgraduate respondent results revert back to the trends exhibited by previous strategic objectives (Table 4.7). The greatest proportion of postgraduate respondents exhibited an increase in TID following use of their respective tools (absolute value of 21, normalised value of 0.5), whilst 14 (normalised value of 0.3) postgraduates did not change their preference in terms of trust. There was a smaller difference between the groups containing postgraduates who displayed no change in trust and those exhibited a decrease in trust (absolute value of 10, normalised value of 0.2). Through analysing the responses it was found that 6 postgraduate respondents could not increase in terms of trust, owing to their responses in the pre interaction questionnaire.

Motivation

The results of this strategic objective (Table 4.6) reveal that only a small number of school respondents exhibited an increase in motivation following use of the tools (absolute value of 6, normalised value of 0.2) and in fact the majority showed no change in motivation following tool use (absolute value of 53, normalised value of 0.8). Only a small number of the respondents reveal that they were less likely to take part in environmental activities as a result of using the tools.

A similar result is revealed for the postgraduate respondent results (Table 4.7). Again, 'no change' was the most represented group, with 42 of the 45 postgraduate respondents exhibiting this behaviour (normalised value of 0.9). There was an increase in motivation in two of the postgraduate respondents (normalised value of 0.2), whereas only 1 postgraduate showed a decrease in motivation following tool use.

Inclusion

Inclusion was analysed in terms of strategic objective promotion across all tools. The results for both the school and postgraduate respondent groups take on a similar trend to that of the results for 'motivation'. The results indicate that the majority of school respondents exhibited 'no change' (absolute value of 50, normalised value of 0.8) whilst 8 individuals displayed an increase in inclusion (normalised value of 0.5). Only 2

individuals displayed a decrease in inclusion (normalised value of less than 0.1) (Table 4.6).

Where postgraduate respondents were questioned in order to reveal whether their respective ICT tools promoted inclusion, it was found that the tools did not promote inclusion in the majority of respondents (absolute value of 42, normalised value of 0.9) (Table 4.7). The second largest proportion was associated with an increase in inclusion (absolute value of 2, normalised value of 0.7) whilst the smallest proportion revealed that following tool use the respondents considered certain environmental issues not to be problems with which they would be concerned with.

4.3.3 Breakdown of strategic objective by tool

This section concentrates on the degree to which each of the four tools evaluated promoted each of the short listed strategic objectives. This allows a direct comparison of the degree to which strategic objectives are promoted across the four tools. Again the results are presented in absolute and normalised formats for reasons explained in section 4.3.1. The results are displayed by first presenting the data collected from the evaluations involving the school respondents and then the postgraduate results.

Table 4.8 School respondent results by tool and strategic objective

Riverside Explorer							
Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	7 (0.4)	7 (0.4)	2 (0.2)	16/16	0	12	4
TII	7 (0.4)	7 (0.4)	2 (0.1)	16/16	0	16	0
TICT	11 (0.7)	4 (0.3)	1 (0.1)	16/16	0	16	0
TID	5 (0.4)	5 (0.3)	6 (0.4)	12/16	4 (1 nc, 3 dec)	10	6
Motivation	1 (0.1)	15 (0.9)	0	9/16	7 (7 nc)	7	9
Inclusion	2 (0.4)	13 (0.8)	1 (0.1)	5/16	11 (10 nc, 1 dec)	11	5
Ecopod							
Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	10 (0.7)	5 (0.3)	0	14/15	1 (1 nc)	11	4
TII	6 (0.4)	8 (0.5)	1 (0.1)	14/15	1 (1 nc)	15	0 (2 no)
TICT	7 (0.6)	6 (0.4)	2 (0.1)	12/15	3 (2 nc, 1 dec)	15	0 (2 no)
TID	9 (0.6)	6 (0.4)	0	14/15	1 (1 nc)	15	0
Motivation	1 (0.2)	14 (0.9)	0	5/15	10 (10 nc)	10	5
Inclusion	6 (0.9)	9 (0.6)	0	7/15	8 (8 nc)	9	6

Table 4.9 School respondent results by tool and strategic objective

Personal Barometer							
Strategic Objective	**Absolute Values (proportional values in brackets)**						
	Increase	No Change	Det/ Decrease	Number could improve	Number couldn't improve	Number who could get worse	Number couldn't get worse
Learning	10 (0.8)	2	2 (0.3)	13/14	1 (1 det)	8	6
TII	7 (0.5)	3 (0.2)	4 (0.3)	13/14	1 (1 nc)	0	0 (1 no)
TICT	8 (0.6)	4 (0.2)	2 (0.1)	13/14	1 (1 nc)	0	0 (1 no)
TID	4 (0.4)	8 (0.6)	2 (0.1)	11/14	3 (2 nc, 1 dec)	13	1
Motivation	4 (0.6)	10 (0.7)	0	7/14	7 (7nc)	7	7
Inclusion	0	13 (0.9)	1 (0.1)	4/14	9 (8 nc, 1 dec)	10	4
Water Aid Game							
Strategic Objective	**Absolute Values (proportional values in brackets)**						
	Increase	No Change	Det/ Decrease	Number who could improve	Number couldn't improve	Number who could get worse	Number couldn't get worse
Learning	6 (0.4)	5 (0.3)	4 (0.4)	15/15	15	11	4
TII	9 (0.8)	5 (0.3)	1 (0.1)	12/15	1 (1 dec)	0	0 (1nr)
TICT	8 (0.7)	5 (0.3)	2 (0.1)	12/15	3 (2 nc, 1 dec)	0	0 (1 nr)
TID	7 (0.8)	8 (0.5)	0	9/15	6 (6 nc)	0	0
Motivation	0	14 (0.9)	1 (0.1)	4/15	11 (10 nc, 1dec)	11	4
Inclusion	0	15 (1.0)	0	1/15	14 (14 nc)	14	1

Table 4.10 Postgraduate results by tool and strategic objective

Riverside Explorer							
Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	5 (0.5)	5 (0.5)	0	10/10	1 [1 det]	8	2
TII	3 (0.3)	7 (0.1)	0	9/10	1 [1 nc]	9	1
TICT	4 (0.4)	6 (0.6)	0	10/10	0	0	0
TID	3 (0.4)	2 (0.2)	5 (0.5)	8/10	2 [1nc, 1 dec]	0	0
Motivation	0	10 (1.0)	0	2/10	8 [8 nc]	8	2
Inclusion	1 (1.0)	8 (0.8)	1 (0.1)	1/10	9 [8 nc, 1 dec]	9	1
Ecopod							
Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	5 (0.6)	5 (0.4)	2 (0.2)	8/12	4 [3 nc, 1det]	12	0
TII	6 (0.5)	5 (0.4)	1 (0.1)	12/12	0	12	0 (1no)
TICT	6 (0.5)	4 (0.3)	2 (0.2)	12/12	0	12	0 (2no)
TID	5 (0.5)	4 (0.3)	3 (0.3)	11/12	1	0	0
Motivation	1 (0.5)	11 (0.9)	0	2/12	10 [10 nc]	10	2
Inclusion	0	12 (1.0)	0	1/12	11 [11 nc]	11	1

Table 4.11 Postgraduate results by tool and strategic objective

Personal Barometer							
Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	5 (0.7)	6 (0.5)	1 (0.2)	7/12	5 [5nc]	11	1
TII	9 (0.8)	3 (0.3)	0	12/12	0	12	0 (2no)
TICT	9 (0.8)	3 (0.3)	0	12/12	0	12	0 (2no)
TID	6 (0.5)	4 (0.3)	2 (0.2)	11/12	1 [1 dec]	12	0
Motivation	0	11 (0.9)	1 (0.1)	0/12	12 [12 nc]	12	0
Inclusion	1 (1.0)	11 (0.9)	0	1/12	11 [11 nc]	11	1
Water Aid Game							
Strategic Objective	**Absolute Values (Normalised values in brackets ())**						
	Increase	No Change	Deterioration / Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Learning	7 (0.6)	2 (0.2)	2 (0.2)	11/11	5 [5 nc]	10	1
TII	7 (0.6)	3 (0.3)	1 (0.1)	11/11	0	11	0
TICT	7 (0.8)	3 (0.3)	1 (0.1)	9/11	2	11	0 (3no)
TID	7 (0.8)	4 (0.4)	0	9/11	2 [2 nc]	11	0
Motivation	1 (0.2)	10 (0.9)	0	5/11	6 [6 nc]	6	5
Inclusion	0	11 (1.0)	0	0/11	11 [11 nc]	11	0

Learning

The results obtained from the evaluation involving the school respondents revealed that those that interacted with the Personal Barometer showed the greatest learning improvement (absolute value of 10, normalised value of 0.8), followed by those that used the Ecopod tool (absolute value of 10, normalised value of 0.7) (Table 4.8 and 4.9, Figure 4.3). The Riverside Explorer (absolute value of 7, normalised value of 0.4) and the Water Aid Game (absolute value of 6, normalised value of 0.4) promoted learning to a similar but lower degree. Those individuals that interacted with the Riverside Explorer exhibited the highest non improvement values for the learning strategic objective (absolute value of 7, normalised value of 0.4), followed by the Water Aid Game (absolute value of 5, normalised value of 0.3) and Ecopod (absolute value of 5, normalised value of 0.3). The Personal Barometer showed the smallest value of this category. Finally, a significant number of the school respondents who interacted with the Water Aid Game (absolute value of 4, normalised value of 0.4) exhibited a deterioration in learning and when compared to other tools. A small proportion of individuals who interacted with the Personal Barometer (absolute value of 2, normalised value of 0.3) and the Riverside Explorer (absolute value of 2, normalised value of 0.2) also deteriorated in terms of learning.

The results from the postgraduate respondents (Table 4.10 and 4.11, Figure 4.4) reveal that for learning improvement and considering the normalised results the Personal Barometer (absolute value of 5, normalised value of 0.7) promoted learning in the greatest proportion of postgraduate respondents, followed by the Water Aid Game (absolute value of 7, normalised value of 0.6) and Ecopod (absolute value of 5, normalised value of 0.6). The Riverside Explorer was found to promote learning to the least degree in postgraduate evaluation responses, when considering the normalised results (absolute value of 5, normalised value of 0.5). When comparing the non improvement category across all tools, the Personal Barometer scored highly (absolute value of 6, normalised value of 0.5) followed by the Riverside Explorer (absolute value of 5, normalised value of 0.5), followed by Ecopod (absolute value 5, normalised value

of 0.4) and the Water Aid Game (absolute value of 2, normalised value of 0.2). Only a small proportion of those individuals that used the Personal Barometer showed no improvement in learning following interaction with the tool. Of the few individuals that displayed learning deterioration following tool use, when comparing the tools, the Water Aid Game (absolute value of 2, normalised value of 0.2) and Ecopod (absolute value of 2, value of 0.2) showed the highest proportions of respondents followed by the Personal Barometer (absolute value of 1, normalised value of 0.2). No postgraduate respondents who used the Riverside Explorer displayed a deterioration in learning.

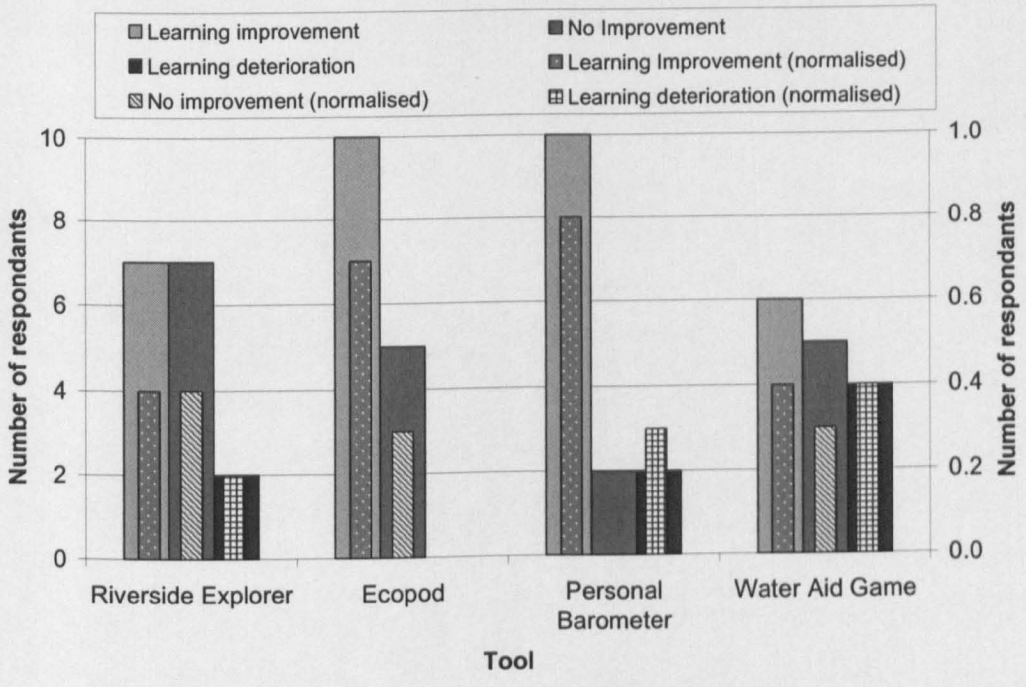

Figure 4.3 The impact that the tools had on learning in school respondents reported in terms of absolute and normalised values

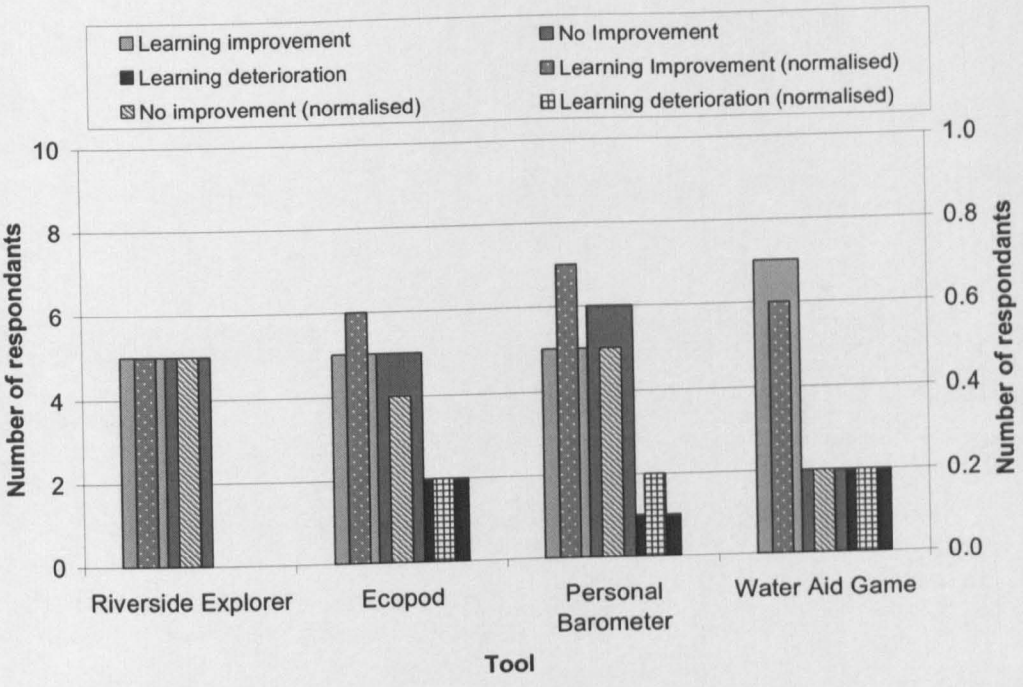

Figure 4.4 The impact that the tools had on learning in postgraduate respondents reported in terms of absolute and normalised values

Trust in the institution

When school respondents were asked if they trusted the institutions (TII) that developed the ICT tools it was found that the respondents that used the Water Aid Game (absolute value of 9, normalised value of 0.8) showed the greatest increase in trust following tool use, followed by the Personal Barometer (absolute value of 7, normalised value of 0.5) (Table 4.8 and 4.9). Both the Riverside Explorer (absolute value of 7, normalised value of 0.4) and Ecopod (absolute value of 6, normalised value of 0.4) promoted an increase in this objective but to a lesser degree when compared with the other tools. Following use of Ecopod (absolute value of 8, normalised value of 0.5), a larger proportion of respondents did not exhibit a change in TII (compared with the learning improvement group that interacted with Ecopod), whilst following use of the Riverside Explorer, 7 individuals did not improve (normalised value of 0.4). A comparatively small number of users who interacted with either the Water Aid Game (absolute value of 5, normalised value of 0.3) or the Personal Barometer (absolute value of 3, normalised value of 0.2) exhibited no change in TII. Finally when comparing all tools in terms of decrease in trust, the Personal Barometer (absolute value of 4, normalised value of 0.3)

was found to have the largest number of respondents who showed this, compared with the other tools, followed by the Riverside Explorer (absolute value of 2, normalised value of 0.1). After use of the Water Aid Game (absolute value of 1, normalised value of 0.1) and Ecopod (absolute value of 1, normalised value of 0.1), only a few respondents showed a decrease in TII (Table 4.8 and 4.9).

Where the postgraduate respondents took part in the tool evaluation to determine the promotion of TII it was found that the greatest increase in trust resulted from respondents using Personal Barometer (absolute value of 9, normalised value of 0.8), followed by the Water Aid Game (absolute value of 7, normalised value of 0.6), Ecopod (absolute value of 6, normalised value of 0.5) and the Riverside Explorer (absolute value of 3, normalised value of 0.3) (Table 4.10 and 4.11). The Riverside Explorer (absolute value of 7, normalised value of 0.1) was the tool that had the highest proportion of respondents that exhibited a 'no change' in trust, followed by the Ecopod (absolute value of 5, pro 0.4) tool and the Water Aid Game (absolute value of 3, normalised value of 0.3) and the Personal Barometer (absolute value of 3, pro 0.3). However, when viewing the normalised results, Ecopod scored the most (0.4), followed by the Water Aid Game and the Personal Barometer (both with 0.3) and finally the Riverside Explorer (0.1) Only use of Ecopod and the Water Aid Game resulted in a decrease in trust in respondents.

Trust in the computer tool

The results of this second element of trust or 'trust in the computer tool' (TICT) are displayed in Tables 4.8 and 4.9. Across all tools, the majority of school respondents exhibited an increase in trust in the computer tool, following tool use. Of these, the Riverside Explorer (absolute value of 11, normalised value of 0.7) and the Water Aid Game (absolute value of 8, normalised value of 0.7) promoted this objective to the greatest degree and the Personal Barometer (absolute value of 8, normalised value of 0.6) and Ecopod (absolute value of 7, normalised value of 0.6) to a slightly less degree. Where tool use had no affect, or the respondents exhibited no change in TICT, a greater number of school respondents that interacted with Ecopod (absolute value of 6, normalised value of 0.4) showed this when compared to the other tools. All of the other

tools had comparatively smaller numbers (both absolute and normalised values) of individuals who showed no change in TICT. A relatively small number of individuals displayed a decrease in this form of trust across all of the tools.

Postgraduate results for this strategic objective are shown in Table 4.10 and 4.11. Following use of the Personal Barometer (absolute value of 9, normalised value of 0.8) and the Water Aid Game (absolute value of 7, normalised value of 0.8) the largest proportion of postgraduate respondents showed an increase in TICT. Use of both the Ecopod (absolute value of 6, normalised value 0.5) tool and the Riverside Explorer (absolute value of 4, normalised value of 0.4) resulted in an increase in TICT amongst some respondents, but to a comparatively smaller degree. The highest proportion of 'no change' results was found in respondents that had interacted with the Riverside Explorer (absolute value of 6, normalised value 0.6), for this tool, the number of postgraduate respondents that showed no change was higher than the group that exhibited an increase in trust. A decrease in trust in the computer tools only resulted following use of the Ecopod tool (absolute value of 2, normalised value of 0.2) and the Water Aid Game (absolute value of 1, normalised value of 0.1) by postgraduate respondents

Trust in decisions made

Following tool use, each respondent was asked to rate their confidence in a decision they were asked to make during a discussion session. It was found that respondents were most confident in this decision making following use of the Water Aid Game (absolute value of 7, normalised value of 0.8) compared with the other tools. When comparing the respondents that interacted with the other tools, a smaller proportion of those who interacted with Ecopod (absolute value of 9, pro 0.6), the Riverside Explorer (absolute value of 5, normalised value of 0.4) and the Personal Barometer (absolute value of 4, normalised value of 0.4) tools demonstrated an increase in this type of trust. Following used of the Personal Barometer, the majority of respondents exhibited no change (absolute value of 8, normalised value of 0.6), followed by the Water Aid Game (absolute value of 8, normalised value of 0.5), Ecopod (absolute value of 6, normalised

value of 0.4) and the Riverside Explorer (absolute value of 5, normalised value of 0.3) . Finally, when compared with the other tools, Personal Barometer (absolute value of 8, normalised value of 0.6) and the Water Aid Game (absolute value of 8, normalised value of 0.5) displayed a decrease in trust. The majority of individuals that used either the Personal Barometer or the Water Aid Game did not change in terms of trust. No school respondents that interacted with Ecopod showed a decrease in TID.

Where TID promotion was considered following the evaluation involving the postgraduate respondents, the Water Aid Game (absolute value of 7, normalised value of 0.8) promoted this objective to the highest degree, followed by the Personal Barometer (absolute value of 6, normalised value of 0.5), Ecopod (absolute value of 5, normalised value of 0.5) and the Riverside Explorer (absolute value of 3, normalised value of 0.4) (Table 4.10). When considering the absolute values the Water Aid Game, Ecopod and the Personal Barometer all displayed similar 'no change' results. However, three of the tools, the Riverside Explorer, Ecopod and the Personal Barometer all had negative impacts on some respondents with respect to this strategic objective.

Motivation

The results of the section of the evaluation which tested the promotion of motivation by the ICT tools differed greatly from previously mentioned strategic objectives. For both school (Table 4.8 and 4.9) and postgraduate (Table 4.10 and 4.11) respondents, the results show that following tool use the majority of respondents did not change their views on helping solve local environment problems. When looking at the results from the school respondent evaluations it was found that the Personal Barometer, Ecopod and Riverside Explorer tools promoted an increase in motivation in some cases, the most motivated respondents being those that interacted with the Personal Barometer.

There was even less impact on postgraduate motivation following tool use, however Ecopod appeared to increase motivation.

Inclusion

When the ICT tools were tested on school respondents to determine whether they promoted inclusion, it was found that only two tools, Ecopod and the Riverside Explorer promoted this strategic objective (Table 4.8 and 4.9). The majority of respondents did not change their opinions following use of the tools. Only two tools caused a decrease in inclusion in a small proportion of respondents after interaction and these were the Riverside Explorer and the Personal Barometer.

From the results of the postgraduate evaluations it was found that interaction with the Riverside Explorer and Personal Barometer promoted inclusion to the greatest degree, (Table 4.10 and 4.11). No respondents that interacted with the Water Aid Game and Ecopod tools exhibited an increase in feelings of inclusion and a large majority did not following use of the Personal Barometer or the Riverside Explorer. For all tools the majority of postgraduate respondents exhibited no change in feelings of inclusion.

Openness

After the pre and post scenario discussions, the respondents were asked to judge how fair they considered the other members of their group to be. ICT tools promote openness by being publically accessible sources of knowledge and by presenting information in a commonly recognizable format. As such, the tools act as a common reference point for debate and dialogue. Openness can therefore be measured by asking respondents how fair they perceive each other to be. The data is presented as both absolute and normalised results (Tables 4.12-4.14).

Table 4.12 Openness

Key

nc - no change

det - deterioration

dec - decrease

nr - no response

Strategic Objective	**Absolute Values (normalised values in brackets ())**						
Openness Group	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
School	28 (0.6)	19 (0.3)	13 (0.2)	48	12 [9 nc, 3 dec]	60	0
Postgraduate	25 (0.6)	14 (0.3)	6 (0.1)	40	5 [4 nc, 1 det]	45	0

Table 4.13 School respondents results for openness

	Absolute Values (normalised values in brackets ())						
	Increase	No Change	Deterioration/ Decrease	Number who could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Riverside Explorer	6 (0.4)	4 (0.3)	6 (0.4)	16/16	0	16	0
Ecopod	8 (0.7)	6 (0.4)	1 (0.1)	11/15	4 [nc]	15	0
Personal Barometer	6 (0.5)	5 (0.4)	3 (0.2)	13/14	1 [nc]	14	0
Water Aid Game	8 (1.0)	4 (0.3)	3 (0.2)	8/15	7 [4nc, 3 dec]	15	0

Table 4.14 Postgraduate Respondents for openness

	Absolute Values (normalised values in brackets ())						
	Increase	No Change	Deterioration Decrease	Number could improve	Number who could not improve	Number who could get worse	Number who could not get worse
Riverside Explorer	5 (0.5)	2 (0.2)	3 (0.3)	10 10	0	10	0
Ecopod	9 (0.8)	1 (0.1)	2 (0.2)	12 12	0	12	0
Personal Barometer	8 (0.7)	3 (0.3)	1 (0.1)	11 12	1 [dec]	12	0
Water Aid Game	3 (0.4)	8 (0.7)	0	7 11	4 [nc]	11	0

Overall, it was found that following use of the tools by both the school and postgraduate respondent groups, openness was increased. When the school students were asked to judge their fellow evaluators, it was found that the Water Aid Game promoted openness to the highest degree compared to the other tools. Ecopod, the Personal Barometer and the Riverside Explorer all promoted openness to lesser degrees (Table 4.12). The tool that caused the largest decrease in openness was the Riverside Explorer.

In Table 4.13, the results of the postgraduate responses for 'openness' are shown. Openness was found to increase to a greater degree following tool use, promoted to the highest degree by Ecopod and the Personal Barometer. A large proportion of respondents who interacted with the Water Aid Game exhibited no change in openness. A decrease in openness was seen in those groups that interacted with the Riverside Explorer, Ecopod and the Personal Barometer.

Justice

ICT tools can promote a sense of justice amongst users. In particular, by allowing users to explore the relationships between processes or phenomena and by creating a common claim to the credibility of information, decision or decision processes may be deemed fairer. To determine whether the tools evaluated promoted a sense of justice, the scenario discussions were recorded and the transcripts analysed. Evidence of agreement (and meaning that all respondents had an input in the discussion) by all respondents within each group was searched for and is presented in Tables 4.15 and 4.16.

Table 4.15 Incidences of evidence of justice promotion by tools following use by school respondents

Tools	Incidences of justice promotion following tool use (by tool type).
Riverside Explorer	6
Ecopod	10
Personal Barometer	5
Water Aid Game	8

Table 4.16 Incidences of evidence of justice promotion by tools following use by postgraduate respondents

Tools	Incidences of justice promotion following tool use (by tool type)
Riverside Explorer	16
Ecopod	11
Personal Barometer	4
Water Aid Game	12

4.3.4 *Comparison of the ability of the tested ICT tools to promote the strategic objectives*

Once the degree to which each of the tools promoted each strategic objective was calculated using the normalisation procedure, the tools could be compared to see which promoted the tools to the highest degree. A suitable indicator for comparison was based on the tools which promoted 50% improvement in the respondents that interacted with them. Table 4.17 shows the results for the student respondents and Table 4.18 for the postgraduate respondents.

Table 4.17 School respondent results based on an improvement of 50% of all those who could improve.

Strategic Objective	Riverside Explorer	Ecopod	Personal Barometer	Water Aid Game
Learning	×	✓	✓	×
Trust in Institution	×	×	✓	✓
Trust in content of the tool	✓	✓	✓	✓
Trust in decisions made following tool use	×	✓	×	✓
Motivation	×	×	✓	×
Inclusion	×	✓	×	×
Openness	×	✓	✓	✓
Total	1	5	5	4

Table 4.18 Postgraduate respondent results based on an improvement amongst 50% of all those who could improve.

Strategic Objective	Riverside Explorer	Ecopod	Personal Barometer	Water Aid Game
Learning	✓	✓	✓	✓
Trust in Institution	×	✓	✓	✓
Trust in content of the tool	×	✓	✓	✓
Trust in decisions made following tool use	×	✓	✓	✓
Motivation	×	✓	×	×
Inclusion	✓	✓	✓	×
Openness	✓	✓	✓	×
Total	3	7	6	4

The results show that for both the respondent groups, Ecopod and the Personal Barometer were the most effective scoring tools.

4.3.5 *Exploration of potential demographic determinants of variation in experimental results*

This section presents an exploration of the potential influences on experimental results. This thesis investigation was conducted to determine the degree to which ICT tools prompted the selected strategic objectives. In order to more fully explore these results to see whether demographic characteristics had an influence on the results, statistical tests were carried out. When considering whether to conduct statistical analysis on the results, first the characteristics of the data set should be considered and Table 4.19 provides a summary of this.

Table 4.19 Data characteristics

Variable	Number
Total number of respondents	105
School respondents	60
Postgraduate respondents	45
Total number of evaluation sessions	28
Evaluation sessions (school)	16
Evaluation sessions (Postgraduate)	12
Number of evaluation sessions per tool (School)	4
Number of evaluation sessions per tool (postgraduate)	3

The data characteristics should also be considered as they aid in the selection of a statistical analysis method, and more importantly the type of sample data that has been collected. In this thesis the responses to the questionnaires yielded discrete data, rather than continuous. Also when considering the potential influences on the experimental results, discrete variables were also considered such as the effects of gender on strategic objective promotion as well as effects within groups, whether school respondent group, or postgraduate respondent group. Other potential influences which were explored included age of respondents from both groups as well as length of residency in the UK. Table 4.20 details the independent variable types and the dependent variables they have tested against.

The discrete nature of the sample data dictated the statistical analysis methods which could be used. The best way to test any influences in this case is to use a Pearson's chi square test, and this was calculated using SPSS. The outcomes are presented in Table 4.21.

Table 4.20 The independent and dependent variables set out to determine how the sample data could be analysed statistically

Independent variables	**Variable type**	**Dependent variables**
Respondent Gender	Male/Female (Bivariate)	Learning Trust in institution Trust in content of the tool Trust in decisions made following tool use Motivation Inclusion
Respondent Group	School / Postgraduate (Bivariate)	Learning Trust in institution Trust in content of the tool Trust in decisions made following tool use Motivation Inclusion
Respondent Age	Integer	Learning Trust in institution Trust in content of the tool Trust in decisions made following tool use Motivation Inclusion
Length of residency in the UK	Integer	Learning Trust in institution Trust in content of the tool Trust in decisions made following tool use Motivation Inclusion

Table 4.21 Outcomes of the demographic determinants of variation in the experimental results.

Variable	Strategic Objective	Chi Square value	Number of cells with an expected count < 5
Gender	**Learning**	0.371	0
	Trust in institution	0.818	1
	Trust in content of the tool	0.340	1
	Trust in decisions made following tool use	0.748	0
	Motivation	0.436	4
	Inclusion	0.298	3
Respondent Group	**Strategic Objective**	**Chi Square value**	**Number of cells with an expected count < 5**
	Learning	0.673	0
	Trust in institution	0.299	1
	Trust in content of the tool	0.671	1
	Trust in decisions made following tool use	0.272	0
	Motivation	0.561	4
	Inclusion	0.281	3
Age 1-20 21-30 31-40	**Strategic objective**	**Chi Square value**	**Number of cells with an expected count < 5**
	Learning	0.965	3
	Trust in institution	0.622	3
	Trust in content of the tool	0.684	3
	Trust in decisions made following tool use	0.260	3
	Motivation	0.242	6
	Inclusion	0.558	5
Length of residency in the UK Less than 1 year More than 1 year	**Strategic Objective**	**Chi Square value**	**Number of cells with an expected count < 5**
	Learning	0.666	1
	Trust in institution	0.158	1
	Trust in content of the tool	0.493	1
	Trust in decisions made following tool use	0.348	1
	Motivation	0.174	3
	Inclusion	0.095	3

Statistical analysis was also carried out to determine whether there was a significant difference in strategic objective promotion between the school and postgraduate respondent groups. This was again carried out by using a Pearson Chi square test, determined using SPSS. The results are shown in Table 4.21. Further chi square tests were also conducted to determine whether respondent age influenced strategic objective promotion and also length of residency in the UK.

It was found that there was no significant difference between males and females in terms of strategic objective promotion, or between school and postgraduate respondents. This was also the case for both the age and length of residency in the UK (Table 4.21).

4.4 Results of the expert evaluations

The final evaluation activity involved experts from both industry and academia. Their expertise ranged from software evaluation and ICT tool design. The experts were asked to judge the degree to which each of the four tools promoted the strategic objectives. The experts' evaluations were conducted on an individual basis and each expert was given a definition sheet which provided an explanation of each strategic objective so that all respondents understood the objectives in the same way. The respondents judged each of the four tools using a Likert Scale which ranged from 1 (no promotion of strategic objectives) to 10 (promotes strategic objective to a high degree). The results of the expert evaluations are shown in Table 4.22. The strategic objectives were judged to be promoted if experts allotted a score, of four or greater. This was to provide an indication of strategic objective promotion so that the tools could be compared. If no response was given, or where the respondent marked the 'no opinion' option, a score of 0 was awarded. The total mean scores across all responses for each objective were also determined to see what the mean score was across all strategic objectives.

The experts that took part in the evaluations are identified as A, B, C and D for the purposes of this investigation. During the evaluations the experts were asked to judge the degree to which each of the ICT tools promoted each strategic objective. They did

this by interacting with each of the four tools and then were asked to indicate on a Likert scale (where a score of one indicated that the tool did not promote the strategic objective and a score of 7 indicated that the tool was considered to have promoted the objective). Table 4.23 shows the degree to which each strategic objective was judged to be promoted by each of the tools. The values were calculated by adding the scores given by each of the four experts on the Likert scale, to find a total score for each objective per tool. The total scores for each strategic objective across all tools are also presented. These calculations enabled the ranking of the strategic objectives to determine which strategic objectives were judged to be promoted to the greatest degree by the tools compared to other strategic objectives. This ranking is shown in Table 4.24.

The experts were also asked to make a direct comparison of the tools in terms of strategic objectives promotion. The scores with which the experts awarded each tool were summed, so each tool had a total score. The results showed that the highest scoring tool was the Riverside Explorer, followed by the Personal Barometer, the Water Aid Game and finally Ecopod (Table 4.25).

Table 4.22 Results of the Experts Evaluation

Strategic objectives	**Tool**																			
	Riverside Explorer				**Mean**	**Ecopod**				**Mean**	**Personal Barometer**				**Mean**	**Water Aid Game**				**Mean**
	A	B	C	D		A	B	C	D		A	B	C	D		A	B	C	D	
Trust	5	5	4	2	4	2	4	1	4	2.75	1	5	4	2	3	3	5	4	0	3
Education (Learning)	6	6	2	2	4	2	3	2	2	2.25	3	5	4	4	3.5	2	6	2	3	3.25
Justice	2	5	1	2	2.5	2	3	1	3	2.25	1	4	1	2	2	2	6	1	2	2.75
Inclusion	1	4	1	2	2	2	3	3	5	3.25	1	4	5	2	3	5	6	1	3	3.75
Commitment (Motivation)	7	6	2	3	4.5	2	5	2	3	3	4	4	5	3	3.5	7	3	2	2	3.5
Openness	3	5	1	1	2.5	2	4	1	2	2.25	2	5	5	1	3.25	4	2	1	0	1.75
Where SO achievement >4	3	5	0	0		0	1	0	1		0	3	3	0		2	4	0	0	
Total (Experts mean)	2					0.5					1.5					1.5				

Table 4.23 Results of the Experts Evaluation –The degree to which strategic objectives were considered promoted by each ICT tool tested.

Strategic objectives	Riverside Explorer	Ecopod	Personal Barometer	Water Aid Game	Overall rank for each strategic objective assessed	Ranking
Trust	16	11	12	12	51	3
Education (Learning)	16	9	16	13	54	2
Justice	10	9	8	11	38	6
Inclusion	8	13	12	15	48	4
Commitment (Motivation)	18	12	16	14	60	1
Openness	10	9	13	7	39	5

Table 4.24 The ranks of the strategic objectives following the experts evaluations

Ranking	Strategic objective
1	Commitment (motivation)
2	Education
3	Trust
4	Inclusion
5	Openness
6	Justice

Table 4.25 The results when the experts were asked to compare the tools to each other

Respondent	Riverside Explorer	Ecopod	Personal Barometer	Water Aid Game
A	8	3	5	6
B	7	4	6	7
C	3	2	5	2
D	2	8	3	3
Total	20	17	19	18

4.5 A comparison of developer, expert and user responses

The results of the expert evaluations were compared to the developers' results to determine the closeness of match between the objectives stated to be considered by the developers when designing the tools and strategic objective promotion as judged by the experts. Table 4.26 shows this comparison.

Table 4.26 A comparison of developer and expert respondent opinion of strategic objectives promotion by each ICT tool (M=Mean, where the strategic objective was considered by the developers and considered promoted by the experts.

Strategic objectives	**Tools**																							
	Riverside Explorer						**Ecopod**						**Personal Barometer**						**Water Aid Game**					
	Respondent						**Respondent**						**Respondent**						**Respondent**					
	Dev	Experts					Dev	Experts					Dev	Experts (mean)					Dev	Experts (mean)				
		A	B	C	D	M		A	B	C	D	M		A	B	C	D	M		A	B	C	D	M
Trust	×	5	5	4	2	4	✓	2	4	1	4	2.75	×	1	5	4	2	3	×	3	5	4	0	3
Education	✓	6	6	2	2	4	✓	2	3	2	2	2.25	✓	3	5	4	4	4	✓	2	6	2	3	3.25
Justice	×	2	5	1	2	2.5	✓	2	3	1	3	2.25	×	1	4	1	2	2	×	2	6	1	2	2.75
Inclusion	×	1	4	1	2	2	✓	2	3	3	5	3.25	✓	1	4	5	2	3	×	5	6	1	3	3.75
Commitment	×	7	6	2	3	4.5	✓	2	5	2	3	3	✓	4	4	5	3	4	×	7	3	2	2	3.5
Openness	×	3	5	1	1	2.5	✓	2	4	1	2	2.25	✓	2	5	5	1	3.25	×	4	2	1	0	1.75
Experts where SO achievement >4	-	3	5	0	0			0	1	0	1			0	3	3	0		-	2	4	0	0	
Total (Experts: Mean)		2						0.5						1.5						1.5				

4.6 Aggregated results by platform and strategic objective

In this final section the aggregated results are presented by ICT tool using data taken from the evaluation sessions involving the school and postgraduate respondents. The first part focuses on each of the four ICT tools tested and presents the degree to which the tools promoted each of the strategic objectives. These results are then presented in a summary table. Finally, results are presented which show the degree to which the ICT tools promoted the strategic objectives when the results for both school and postgraduate respondents are combined. These results were not normalised to enable a percentage score to be calculated, but the results are still comparable to one another.

Table 4.27 shows the results from the evaluation involving both the school respondents and the postgraduate respondents and their interaction with all of the tools. The percentages were determined by calculating the number of respondents that showed an increase in each strategic objective following tool use, for example, an increase in learning. This number was divided by the total number of individuals that evaluated each tool and was multiplied by 100.

This alternative measure was used so that the results obtained from the user respondent evaluations could be put into a ranking table so that the results could eventually be compared to the developers' and experts' evaluations. Concentrating just on those that showed either an improvement or increase, presenting the results in this way would allow the tools to be ranked by looking at the percentage promotion of each strategic objective by each tool and the total across all tools. The results are presented in Tables 4.27, 4.28, 4.29.

Table 4.28 The ranking system for strategic objectives promotion by all four of the ICT tools when used by the school respondents

Rank	Strategic Objective
1	Learning
2	TICT
3	TII
4	Openness
5	TID
6	Inclusion
7	Motivation

Table 4.29 The ranking system for strategic objectives promotion by all four of the ICT tools when used by the postgraduate respondents

Ranking	Strategic Objective
1	Openness
2	TICT
3	TII
4	TID
5	Learning
6	Inclusion
7	Motivation

Table 4.27 The number of respondents from the user groups displayed an improvement or increase in learning.

	Platform							
	Riverside Explorer		**Ecopod**		**Personal Barometer**		**Water Aid Game**	
Respondent	**School**	**Postgrad**	**School**	**Postgrad**	**School**	**Postgrad**	**School**	**Postgrad**
Strategic Objective								
TICT	69%	40%	47%	50%	57%	75%	53%	64%
Learning	44%	50%	67%	42%	71%	42%	40%	64%
TII	44%	30%	40%	50%	50%	75%	60%	64%
Openness	36%	50%	53%	75%	43%	67%	53%	27%
TID	31%	30%	60%	42%	29%	50%	47%	64%
Inclusion	13%	10%	40%	0	0	8%	0	0
Motivation	6%	0	7%	8%	29%	0	0	9%

To determine which strategic objectives were promoted the most amongst all respondents who had used the tools, a ranking system was designed. The results shown in Table 4.30 reveal that TICT was the objective promoted the most out of all the objectives, with learning promoted to the second highest degree. The objective promoted least by the tools was Inclusion.

Table 4.30 Strategic objective ranking according to degree of promotion by ICT tools evaluated.

Ranking	Strategic Objective
1	TICT
2	Learning
3	TII
4	Openness
5	TID
6	Motivation
7	Inclusion

Table 4.31 shows the total values when the improvement or increase results from both user groups are summed. By using a combined score from both user groups could be calculated to determine the degree to which each tool promoted each of the strategic objectives.

A direct comparison of strategic objective promotion across all tools could be carried out which compared the results from the developers, experts and user evaluations. This is shown in Table 4.32.

Table 4.31 The degree to which strategic objectives were promoted by each tool across both user groups

	Platform			
	Riverside Explorer	**Ecopod**	**Personal Barometer**	**Water Aid Game**
Strategic Objective				
TICT	58%	48%	65%	58%
Learning	46%	56%	58%	50%
TII	38%	44%	62%	62%
Openness	19%	63%	54%	42%
TID	31%	52%	38%	54%
Inclusion	12%	22%	4%	4%
Motivation	4%	7%	15%	27%

Table 4.32 Direct comparison of the order with which strategic objectives were considered by the developers, promoted through use of the tools by the users and judged to be promoted by the experts.

Strategic Objective Ranking	Developers	Users	Experts
1	Education	TICT	Commitment (motivation)
2	Commitment (motivation)	Learning	Education
3	Inclusion Openness	TII	Trust
4	Trust Justice	Openness	Inclusion
5		TID	Openness
6		Motivation	Justice
7		Inclusion	

4.7 Summary

This results chapter has presented the findings of the evaluation sessions involving the developers of the four ICT tools, the Riverside Explorer (The Environment Agency, Ecopod (The Environment Agency), the Personal Barometer (Cranfield University) and the Water Aid Game (Water Aid). The results involving the school and postgraduate respondents were shown, as well as the results of the experts evaluation. The aggregated results were displayed in the final section of this chapter.

5 Discussion

The results reported in Chapter 4 will be discussed in the following pages. Chapter 5 is broken down into five sections. Section 5.1 provides a discussion of each individual strategic objective, taking into account the results of all the evaluation sessions that were conducted. A discussion focussing on a comparative assessment of the four tools is presented in Section 5.2. and Section 5.3 discusses the aggregated results by platform and strategic objective. Section 5.4 reflects on the research method and finally Section 5.5 summarises the chapter's main points.

5.1 Strategic Objectives

It will be recalled that the strategic objectives under consideration are learning, the three elements of trust (trust in the institution, trust in the content of the tool, and trust in decisions made following tool use), motivation, inclusion, justice and openness. The normalised results will be the focus of this discussion, because this is the only way in which the tools can be fairly compared.

5.1.1 Learning

When considering the proportion of individuals that could improve in both groups, an identical number did, with both the school and postgraduate groups scoring a normalised value of 0.6. However, the number of postgraduate respondents that exhibited no change was higher than in the school respondent group. More individuals in the school respondent group displayed a learning deterioration than in the postgraduate group.

These results reveal that there is little difference between the ability of the school respondents and postgraduate respondents to answer questions relating to the content of the tools and that of those respondents that could exhibit an improvement in learning, the majority did in both respondent groups. The results imply that, as the majority of respondents in both groups displayed a learning improvement, overall the tools could be

used as a source of information for both groups, whether they were school respondents or postgraduates.

When looking at the absolute numbers for both groups, most of the respondents could have potentially exhibited a learning improvement following tool use, with more school respondents being able to do so following the pre interaction questionnaire. Compared with the school respondents, a greater proportion of postgraduates answered all of the learning questions correctly in the pre interaction questionnaire. This had a major bearing on the results and could be explained by the fact that a greater proportion the postgraduate respondents were more knowledgeable about the water environment so were therefore able to answer more of the learning questions in the pre interaction questionnaire. Due to the age, number of years in education and fields of expertise, it is likely that more of the postgraduate respondents would achieve 100% in the learning questions before tool use. This could explain why a greater proportion of postgraduates exhibited no change compared to the school respondent group. There may also have been a difference in interpretation of the questions amongst different respondent groups which almost certainly would have had a bearing on the results.

A greater proportion of school respondents exhibited a learning deterioration, which could be for a number of reasons. The school respondents may have got confused by the information presented within the ICT tools, so when they went on to complete the post interaction questionnaire, answered fewer questions correctly, or perhaps a lack of confidence in their answers to the pre interaction questionnaire caused them to answer differently in the post questionnaire. Finally, there may have been a lack in concentration in the younger respondent group, which would make it difficult for them to answer the learning type questions, which required them to recall information. The school respondents took part in the evaluation sessions at various times of the school day, one school opting to conduct the sessions in the morning, two during the lunch break and one after school. Those respondents giving up their lunch hour, or time after school may have particularly felt the effects of tiredness, and consequently lacked concentration.

The fact that the greatest proportion of respondents from both groups showed learning improvement can be compared back to the evaluations involving the developers. When the developers were asked which strategic objectives they considered during the design of their prospective ICT tools, all of them stated that they considered education (learning). This outcome was expected as the ICT tools selected for this thesis investigation were all developed to provide water environment education. The results indicate that across all tools, the greatest proportion of respondents were learning from them, coinciding with the developers' objectives for the tools.

As well as looking at the results for learning across all of the tools, the way in which each tool promoted learning was investigated. The high proportion of respondents who learnt from the tools can be explained as a function of the intended target audience of each tool. The way in which the Personal Barometer was designed can provide clues as to why learning was promoted to a greater degree in this tool compared with the others. The respondents are able to interact to a certain degree with all of the tools, but use of the Personal Barometer requires respondents to use knowledge of their own water uses as input to the tool. By focussing on the user's lifestyle, the users themselves may be more interested in learning from a tool with such a high level of interactivity, thereby facilitating the promotion of learning in this context. Water conservation is an important issue that can be tackled by the respondents in their own home, by following the conservation options in each of the tools. This may have aided learning by the respondents who interacted with the Personal Barometer.

The other tools vary in terms of interactivity and this could have affected the promotion of learning across respondent groups. Amongst the school respondents, the second largest group that exhibited improvement was that which interacted with the Ecopod tool, whilst it was the Water Aid Game for the postgraduate group. Like the Personal Barometer, Ecopod focuses on water conservation in the home, something that can easily be reflected upon by the school respondents in terms of water use in their own homes. Unlike the Personal Barometer however, the Ecopod tool lacks interactivity, for a couple of reasons. Firstly, Ecopod does not allow the input of actual data from the respondents using the tool, therefore it offers no indication of the respondents household

water consumption, so there is no meaningful outcome. Secondly, this tool only allows the respondent very limited movement throughout the tool, it presents the information as part of a 'game'. This could be the very reason why as a 'game', it appealed more and promoted learning more highly to school respondents compared to their postgraduate counterparts.

The Water Aid Game was the least effective in promoting learning school respondents compared to the other tools. This may be explained by the fact that problems of drought take place overseas, and younger respondents may have limited knowledge of such issues. Little knowledge may stem from little interest or the fact that school respondents perceive that there is little they can do to help the situation other than volunteering to help overseas, getting involved in fundraising activities or donating money to a charity.

When comparing the proportions of postgraduate respondents that showed a learning improvement, the Riverside Explorer was the tool that performed the least well. This again could be explained by looking at the degree of interactivity that this particular tool possesses in terms of the respondents inputting their information into the ICT tool. It would be comparably more difficult for respondents to relate to the issues presented in the Riverside Explorer compared to the Personal Barometer. If interested in river habitat destruction (especially if members of the public were directly affected by certain problems), it would be moderately easy for members of the public to get involved in helping solve environmental issues of this type.

Every single respondent that interacted with the Riverside Explorer had the potential to show a learning improvement, as did those using the Water Aid Game.

Finally, it was found that following the experts' evaluations, when all of the strategic objectives were ranked, education or learning was the second highest ranked strategic objective judged to be promoted across all of the ICT tools. This was considered as being the objective central to the design of such tools for a number of reasons. The first was identified in the literature which accompanied each tool, which was either available online, or in the case of the Riverside Explorer, as a booklet. The CD-ROM based

Riverside Explorer was designed with the central aim of providing secondary school students with information about river habitats in England and Wales, whilst Ecopod (available to users of the internet) was developed for use by individuals with an interest in water conservation. Also online, the Water Aid Game is presented in the educational section of the Water Aid website, where the level of information (in terms of difficulty) presented is adjusted according to age. Finally, the Personal Barometer is CD-ROM based and was designed to promote water conservation in the home (similar to Ecopod). The users explore different rooms within a house and using their knowledge of their own families' water consumption, determine how much water they use over the course of a week. They also have the opportunity to learn about water conservation methods in each room. This tool is the only one which allows users to fully interact, by allowing the input of information regarding their lifestyle and provides feedback regarding their water consumption.

The deployment aspects of the various tools also provide clues as to the reasons why 'education or learning' was an unsurprisingly common objective considered by all developers. The context in which the tools are designed for use by a target audience reveal why education (learning) is an important consideration. All tools could be used either in the home, or in the classroom. The structure of the Riverside Explorer is similar to that of an interactive encyclopaedia, meaning that the tool could be either used in an educational setting, such as the classroom, or used in the home, perhaps as an aid to homework, set around environmental awareness. This tool was sent to schools around the UK explicitly to further environmental awareness. The Personal Barometer, the Water Aid Game and Ecopod could also all be used either in the home or the classroom. They could also be used to support homework for example, but could also further existing knowledge or be used as educational 'games'.

The importance of citizens learning about the environment so that they are able to become more environmentally responsible has been investigated by a number of authors including Grob (1995), Barr (2003) and Schahn and Holzer (1990). Grob developed a model of environmental behaviour, which revealed two main components, environmental problem recognition and factual knowledge about the environment.

Therefore if factual knowledge contributes towards inciting environmental behaviour and the ICT tools evaluated in this thesis investigation promoted learning then they are one effective way of providing knowledge.

This thesis investigation has shown that of those respondents that could show a learning improvement, over half actually did following use of the ICT tools, which indicates that these tools were effective at promoting learning. As Stern (1992) suggests, the source of knowledge is important for encouraging individuals to learn about the environment, and these ICT tools have shown to be an effective source. Costanzo *et al* (1986) focussed on the way in which information was gathered, and use of an effective ICT tool would reduce the need for individuals to search for information about the environmental issues of interest. This study as well as the work of Stern and Costanzo *et al* directly link to the work of Hawthorne and Alabaster (1999) who considered how citizens gather environmental information from the media. They identified that often information from the media is either too technical or complex or even imprecise. Even though use of ICT tools to gather information are very unlikely to replace the media as an information source, this study implies that well designed ICT tools can remove the issues of overcompexity and imprecision. Further, Hawthorne and Alabaster suggest that the information is usually biased. This could also have implications for the trust strategic objective which will be discussed in Section 5.1.2.

Therefore in terms of learning, more work needs to be done to create and provide environmental information so it is easy for individuals to learn about the environment and to take steps to living sustainable lifestyles. ICT tools go some way to doing this and other sources of media could too, although its content may require re-evaluation, including the level of complexity of material presented. The introduction of the concept of Education for Sustainable Development and the new national curriculum subject, Citizenship also provide a source of information about environmental issues to individuals, and it is hoped that by learning about these issues at a young age, individuals will grow up more environmentally responsible. The benefits of incorporating ESD into the school management system are obvious, as well as numerous, and this links with the benefits of teaching citizenship. School pupils learn

both about the environment, the impact that their lifestyles have on the environment and what they can do to reduce this, whilst also learning to take both moral and social responsibility. The latter could potentially have further reaching effects, as citizenship also teaches community involvement and participation as well as the principles of democracy and personal effectiveness in contemporary society, all elements that could potentially motivate individuals to take part in environmental decision making and other stakeholder engagement processes. As previously mentioned in Chapter 2, the Eco-Schools initiative is an example of how these elements link together, using knowledge obtained from ESD and values from citizenship, pupils are able to make decisions about their local school environments. Perhaps in future this could lead to a more inclusive, motivated society in terms of sustainability.

Whatever the reason, in terms of promoting learning, the tools demonstrated that they are useable and were effective when used by both school and postgraduate respondents in terms of promoting this strategic objective. If further research was carried out on different respondent groups it is hypothesised that learning would be promoted across a wide range of different groups.

5.1.2 Trust

Overall, school and postgraduate respondents showed an increase in the two types of trust, trust in the institution (TII) and trust in the computer tool (TICT) following tool use. However, there was one exception, the proportion of school respondents that showed an increase in TID was identical to the proportion of school respondents that showed no change in this form of trust.

In terms of TII, the postgraduate respondent group had a higher proportion of individuals that showed an increase following tool use, when compared to the school respondent group. An identical proportion from each group did not change in terms of this type of trust, whilst neither group displayed a significant proportion of individuals that decreased in trust. Overall postgraduate respondents displayed a greater amount of trust in the institutions whose tools they interacted with compared to school respondents. However, if the school students had not heard of the organisations which

had developed the tools, this could explain the difference. If respondents were not familiar with an organisation, then trusting either the organisation, or the contents of the tool or even the decisions made by the respondents following tool use would be difficult.

When comparing the degree to which the four ICT tools tested promoted TII, it was found that for both respondent groups, the Water Aid Game and the Personal Barometer incited the greatest proportion of respondents who increased in TII following tool use. There may be a reason why a large proportion of respondents showed an increase in TII following the use of these particular tools. Perhaps it is easier for an individual to trust an environmental charity such as Water Aid, or a university, compared to a government run organisation. Further, for the school respondent group who used the Ecopod platform, a higher proportion of the school pupils that used the tool showed that they exhibited no change in levels of trust when compared to those that did increase in trust. If fewer school respondents had heard of the Environment Agency (respondents who interacted with The Riverside Explorer or Ecopod were asked this) then this could explain the differences in results between the school and postgraduate respondent groups. Even though a description of the Environment Agency's main duties was provided, ignorance of an organisation's existence would make it difficult to trust it.

The respondents were also asked whether they trusted the content within a tool (TICT). The results suggest that the greatest proportion of individuals from both respondent groups increased in TICT following tool use. When comparing the tools, the results differ when compared to the previously reported form of trust (TII) in the case of the school respondents. The results indicate that the Riverside Explorer and the Water Aid Game had the greatest impact on the school respondents. One explanation for the large amount of trust in the Riverside Explorer could be because the tool may have been perceived as having a more official status. Again, all of the school respondents were told (if they did not already know), that Water Aid is a charity and perhaps this led them to trust the content within the Water Aid Game to a higher degree, compared with those respondents that interacted with the other tools. The results for the postgraduate

respondent group revealed that the Personal Barometer and the Water Aid Game were the tools that promoted the highest proportion of TICT.

Although very little work has been conducted with regards to whether children and young people trust charities, surveys have been carried out to determine what young people would do for charities and how they relate to them. For example, following the Asian Tsunami on Boxing Day 2004, the children's section of the BBC reported that according to one survey children would like to do more to help charity (BBC, 2005). If the children did not trust the charities then perhaps they would be less inclined to want to help the charities, let alone feel that they would like to give more.

A more in depth study conducted by researchers at the Charities Aid Foundation looked at how young people relate to giving and charity. Using a mixture of qualitative and quantitative research methods, they found that young people defined charity in its widest terms, and included charitable 'acts' and not just something that charitable organisations do. Such charitable acts included helping other people in the community, all in all being good citizens. When asked which charitable acts that they were engaged in, the responses included buying Fair Trade goods, recycling, giving items to charity shops and taking part in fundraising activities. However, the study revealed one negative aspect in terms of raising money, which could in turn have an impact on trust. It was found that young people often felt disempowered because they had limited funds to give to charity, but could offer more to charities than money, for example time. One finding of this study which has a particular bearing on trust was the fact that the young people stated that they would like more information from charities as to how their money was spent and what difference it made. They believed that if they had a clearer idea as to where their money went it would encourage them to donate more funds to charity in the future. This finding could imply that if young individuals are requesting more information, then extra knowledge as to where their donations would go would in turn increase trust. The Water Aid Game does attempt to show young people where their donations go and the results from this thesis investigation show that this ICT tool promoted trust to the highest degree. ICT tools such as the Water Aid Game could work

to promote trust amongst young people, by demonstrating how their donations help in other countries.

The final element of trust which was tested was trust in the decisions made (TID) by the respondents in the scenario discussion following tool use. Within both the postgraduate and school respondent groups, the proportion of respondents who displayed an increase in trust was identical, although the results from the school respondent interactions revealed that a large number of respondents were unaffected by the tool in terms of TID. This meant that although school respondents are less likely to have had any experience in decision making with regards to the environment, they were more confident in their choice of solutions during the scenario discussion, compared with the postgraduate respondents. This can perhaps be explained by considering the perceptions that postgraduates and school respondents have regarding the environment. The younger participants (school students) may possess clear cut ideas as to what they think is desirable within the environment and will act upon those ideas, whereas postgraduate respondents may get bogged down in the scientific details that their choice of decision could incur, such uncertainties being driven by both the tool and other issues or knowledge that they possessed before interacting with the tool. Finally a greater proportion of postgraduates displayed a decrease in trust compared with school respondents. When comparing the ICT tools in terms of TID for both respondent groups, the Water Aid Game promoted the greatest proportion of respondents who increased in TID. The results of TID would also reflect the questions set during the scenario discussion session. During the evaluation sessions, the different scenarios fitting to the water environmental issue that each presented were devised in order to generate a group discussion and decision making process. Although uniformity in terms of decision issue complexity was a core consideration when setting the scenario, any variation may have had an effect on these results. For example, one scenario may have been more complex compared to the other scenarios.

An increase in any of the three kinds of trust could be the result of the tools promoting trust in respondents who interacted with the tools, or enhancing the level of existing trust that respondents possessed before using the tools. However, when using ICT tools

of this type, respondents could be reminded of certain environmental issues which have affected them in the past or a situation where they have felt frustrated with a particular institution, which could result in them becoming more sceptical and could lead to a decrease in trust.

Trust was only explicitly considered as an objective by the developers of Ecopod (the Environment Agency), during its design, but was found to be promoted by all the tools when used by both the school and postgraduate respondents. This latter finding concurs with the results of the experts' evaluation where it was found that trust was the third highest strategic objective judged to be promoted by the tools.

There is a strong link between trust and acquiring the knowledge to become an environmentally responsible citizen. The finding by Hawthorne and Alabaster (1999) that citizens often obtain their environmental information from the media provides such a link. They found that often media often provided information that is considered either too technical, or imprecise, but also that the information is usually biased. These are all factors that could potentially lead to citizens acquiring feelings of frustration at unreliable information and could lead to mistrust. Therefore environmental information should be reported accurately, but also in such a way that the greatest number of individuals can benefit from the information. Also, aside from the media, other sources of information should be promoted, as texts, educational resource packs and ICT tools. Where environmental education resources are provided for teachers for use in the classroom, the teachers must be certain that they can fully trust the content, whether it is an educational pack or ICT tool, and trust that the tool itself would run smoothly.

In this thesis it was found that across all tools, there was an increase in trust in the content of the tools. In her paper, Simon (2004) also considered trust in the content of ICT tools, and during peer evaluations involving a group of tutors discussing a number of issues with regards to ICT tools. They acknowledged that ICT tools could be used to provide information, but argued that the content of the tool itself was a concern. A number of questions were asked of ICT tools during this discussion including:

- Would users trust the information?

- How relevant is the information?
- Does the presentation of the information trivialise it (e.g. if it is part of a game)?'

The findings of this investigation show that the ICT tools tested promoted TICT following tool use and this links with Simons work where it was recognised that the content of the ICT tools themselves was very important. As considered by Hawthorne and Alabaster (1999), Simon also recognised that bias could affect trust. Simon addressed trust issues by suggesting that there is a need to bridge the knowledge gap between the experts and non experts that may be involved in a social learning process. Such a gap may cause a decrease in the amount of trust that the non-experts have for the experts. Bridging this knowledge gap would increase the opportunities for non experts to take part in a social learning process for example and this could lead to an overall increase in trust. This is pertinent when environmentally responsibility is considered beyond lifestyle change to citizens actually taking part in environmental decision making. In his paper, Forester (1999) considered the perception amongst scientists and experts that science is of more worth than lay or local knowledge. This feeling alone could work to cause citizens to become mistrustful of the scientists, experts and decision makers as they undervalue local or lay knowledge.

5.1.3 Motivation (commitment for the developer and expert groups)

When the developers of the ICT tools were asked whether they considered commitment / motivation when they designed their respective tools, only two of the developers stated that they did. These were Cranfield University, the developers of the Personal Barometer tool and the Environment Agency who designed the Ecopod tool.

The results from the school and postgraduate respondent evaluations show that the tools failed to promote motivation (in terms of taking part in helping to solve water environmental activities) in the majority of respondents from both the school and postgraduate groups.

Respondents were generally interested in the environmental issues explained in the tools, but when comparing the two response groups, a higher proportion of the postgraduates failed to be influenced by the tool, compared with school respondents. It is likely that the school respondents have less occupying their spare time compared with the postgraduates who could have more constraints on their time. If they had not previously been aware of the water environmental issues affecting their local area before using the tool, the school respondents could then have been motivated to take part in helping to solve the environmental issues and be more ready to give up their time. However, a few school and postgraduate respondents exhibited no increase in their level of motivation following tool use, this could be due to the respondents being uninterested in the issues themselves, or because they know that others are paid to sort these problems out. This latter view was echoed by one school respondent who stated that they were not bothered about getting involved with environmental issues, stating *"that is what the institution is for"*. In some cases this could be because respondents think that they would not be listened to or of much help if they did get involved. Finally, if an issue does not directly affect the individuals then it is likely that they will remain unmotivated. When analysing a number of public participation case studies Beierle and Cayford (2002) identified participant motivation as an objective of importance and the results indicate that that the tools evaluated in this investigation have failed to promote this particular ambition.

The Water Aid game failed to instil motivation in any of the school students when asked if they would get involved in helping solve environmental issues, and the majority of school respondents did not change their opinions following tool interaction. Only a small proportion of the school students who interacted with the Personal Barometer exhibited an increase in motivation, with this objective being promoted to a small degree by Ecopod and the Riverside Explorer.

Compared to the degree to which motivation was promoted by the tools, when the school respondents participated in the evaluation sessions, this objective was promoted to a lesser degree by the tools when the postgraduate respondents interacted with them. Although the tools failed to incite a change in intended behaviour by the majority of

postgraduates, this objective was promoted to the highest degree by Ecopod and then Water Aid Game. Neither the Personal Barometer nor the Riverside Explorer promoted any kind of motivation in the postgraduate respondents. When comparing these results between the different respondent groups, the only consistent finding is the promotion of motivation by the Ecopod platform.

The results from the school and postgraduate respondent evaluations differ greatly from the experts' evaluation. As a group, the experts suggested that commitment / motivation was the strategic objective promoted by all of the tools to the highest degree compared to all other strategic objectives (when ranked). This difference between expert judgement and evidence from users may be the result of the different evaluation techniques used to carry out this investigation. It may be that an evaluation methodology that is sufficient to reveal the promotion of one type of strategic objective is poor at uncovering another.

The majority of respondents from both groups failed to register an improvement in their motivation levels. This can be explained by considering the difference between the absolute and normalised values, and justifies the need for considering normalised data. The respondents that answered positively in the pre interaction questionnaire would not have been able to improve their motivation score. This was indeed the case for the motivation results recorded in this study. However, by considering the normalised values, this would take into account the respondents that could actually show an increase, no change or decrease in motivation and when comparing the absolute and normalised numbers the trends remain very similar.

The large proportion of motivated individuals revealed before tool use bodes well in terms of overall environmental awareness. This is especially so when considering Barr's 2003 review of factors which effect pro environmental behaviour in which he found that motivation was found to play a key role. Intrinsic motivation or the feeling of satisfaction that some individuals gain from carrying out environmental behaviours was found by De Young and Kaplan (1985-1986) to increase the chances that individuals would continue practising such behaviours. Further, linking with the findings of De

Young and Kaplan, there may be an argument that individuals would feel more satisfied if they were involved in solving issues in their local area. In this study, it was found that a high number of individuals stated in their pre interaction questionnaire responses that they would get involved in helping solve water related environmental issues affecting their local areas, which suggests that this may be the case.

However, when looking at motivation from a slightly different perspective, Baldassare and Katz (1992) and Segun *et. al.,* (1998) found that the threat of environmental problems such as global warming was enough to motivate individuals to change their lifestyle. Individuals would adopt more environmental lifestyles in an attempt to alleviate the environmental problem. This action was therefore related back to perceptions; the individuals making changes must believe that they will have an impact and that they will contribute to solving the problem.

Motivation can also arise through social pressure as investigated by Chan (1998) and Tucker (1999). Those environmental behaviours that can be seen by others (kerbside recycling in a neighbourhood is one such example) may put pressure on non-recyclers to recycle. Normative social pressures as outlined by Oskamp *et al* (1991) also exist in terms of other environment behaviours. These include the use of sprinklers to water the garden, or hosepipes to wash cars. Therefore social pressures regarding environmental behaviour exist and will have an impact on the numbers of individuals that carry out such environmentally beneficial actions. However, this is only for visible actions, rather than environmental practices such as energy saving. There is an interesting link here with the findings that learning was promoted to a reasonable degree by the ICT tools evaluated in this investigation. Those normative social pressures only exist if at first the individuals are actually aware of the environmental issues and what they can do to help alleviate them, for example saving water. Individuals would need to find out about ways to save water and this can be through use of ICT tools. Further work could look at the way in which individuals may experience guilty feelings and how this effects the degree to which they perform environmental behaviours.

5.1.4 *Inclusion*

The developers of Ecopod (Environment Agency) and the Personal Barometer (Cranfield University) both stated that they considered inclusion when designing their tools. These tools both demonstrate a large amount of interactivity, by allowing the user to explore the tool and use information regarding their own daily water consumption. The users are also able to gain information regarding water conservation which they can implement in their own homes. This encourages ownership of the issue of water conservation by linking personal behaviour, attitudes, and utility to personal choices.

However, when inclusion was tested during the school and postgraduate evaluation sessions, most respondents (from both groups) were uninfluenced by tool use. When comparing the respondent groups, a higher proportion of postgraduate respondents displayed an increase in inclusion compared with the school students. There was a decrease in feelings of inclusion in a small proportion of both school and postgraduate respondents. Losing feelings of inclusion following use of the tools could be because the school respondents felt that they didn't need to be included in a decision making process because the organisations that designed each tool were responsible for overcoming such problems. They may have also felt powerless to help with the environmental issues mentioned.

Amongst the school respondents, only Ecopod and the Riverside Explorer promoted this strategic objective to any degree. In the postgraduate group, only the Riverside Explorer and the Personal Barometer promoted inclusion to a small degree. The differences could be explained by the question asked in order to determine whether each tool promoted inclusion. For example, those that interacted with the Riverside Explorer were asked whether they thought wildlife habitat destruction was a problem that they should be concerned with. Those that interacted with either Ecopod or the Personal Barometer were asked whether they thought that water overuse in the home was a problem that they should be concerned with. Finally, those that interacted with the Water Aid Game were asked whether world drought was an issue that they thought they should be concerned with. The way that the questions were posed to the respondents could have had a bearing on the responses; after all, it would perhaps be difficult to answer no to

such questions, even if that was the answer that the respondent did want to put. Again social pressures and the 'extra baggage' that the respondents may have entered the evaluation session with would almost certainly have had an impact on the answers to the questions in the questionnaire. After all, individuals may feel ashamed or guilty for saying that they did not consider wildlife habitat destruction to be something that they should be concerned with.

When conducting her investigations into the evaluation of ICT tools for social learning using a systems approach, Simon (2004), looked at the desirable outcomes of such ICT tools. The ICT tools evaluated in this study were designed so that they could potentially be used to increase inclusion, for example to be used by groups of individuals who are usually ignored during environmental decision making, perhaps because they were considered non experts, or for political or social reasons.

Although it was not widely considered by the developers, and the users evaluation sessions revealed that the tools failed to promote inclusion to any large degree, the results from the experts evaluations revealed that inclusion was judged to be promoted to a reasonable degree, and was ranked more highly than two other objectives.

5.1.5 Justice

Justice is an important strategic objective in terms of environmental knowledge and its links with stakeholder engagement because it is also linked to impressions of fairness. The promotion of justice occurs through the inclusion of all interested parties so that every interested and concerned individual is able to become both environmentally aware and responsible. Part of this thesis investigation considered justice as a strategic objective and whether the ICT tools instilled a sense of justice amongst users.

Amongst the tool developers, justice was only considered by the Environment Agency during the development of the Ecopod tool. However, to investigate this strategic objective further, the promotion of justice was determined by analysing the discussion session transcripts from each of the user groups. The consideration of justice by the developers of Ecopod was reflected in the school respondent results where it was found

that justice was promoted to the highest degree by the Ecopod platform, followed by the Water Aid Game, the Riverside Explorer and the Personal Barometer to the lowest degree. This differed from the postgraduate results, where the Riverside Explorer promoted justice to the highest degree, followed by the Water Aid Game, Ecopod and the Personal Barometer.

In both groups the Personal Barometer scored the least in terms of justice promotion. The Water Aid Game in particular successfully promoted justice in both groups, perhaps by creating a common claim, where the respondents in the group all felt a responsibility or ownership of the issues within the tools. The Water Aid Game also demonstrated to the users that drought in developing countries is a problem that they should be concerned with, as well as allowing the respondents to explore the relationships between the problems of, and solutions to, drought.

Justice was low ranking when compared to the promotion of the other strategic objectives, in the expert evaluation sessions.

5.1.6 Openness

Openness was an objective considered only by the Environment Agency (Ecopod) and Cranfield University (Personal Barometer) in the design of their ICT tools. Both tools are examples of publically accessible sources of knowledge, and are accessible to a wide range of potential users.

In the users' evaluations, the promotion of openness was determined by asking the respondents to rate other group members in terms of how fair they considered each other to have been during the scenario discussion sessions. Openness was promoted by the Water Aid Game to the largest degree, followed by Ecopod, the Personal Barometer and the Riverside Explorer when the school students interacted with the tools. However, in the case of the postgraduate respondents, openness was promoted to a greater degree, especially for those respondents who interacted with the Ecopod and the Personal Barometer. In the postgraduate groups, the Riverside Explorer and the Water Aid Game also promoted openness in postgraduate groups but only in a few individuals. Although those individuals that designed the Water Aid Game did not consider 'openness' as a

strategic objective, this scored highly in the school respondent evaluations. There is a strong correlation between intent of the tool and impact that the tool had in terms of openness when the Personal Barometer was considered. The developers of the Personal Barometer considered this objective during the development stages of their tools. Following the user evaluations, it was found that the Personal Barometer promoted an increase in openness in 50% of respondents. However, this was not the case following the experts evaluations, where when the strategic objectives were compared, openness was judged to be promoted to a lower degree.

When comparing those respondents who displayed a decrease in openness, following tool interaction, larger decreases were seen in the school respondents than amongst the postgraduates. In the school respondent groups, interaction resulted in a decrease in openness in some student groups. However, this was not the case with the postgraduate groups; use of the Water Aid Game did not cause a decrease in openness, whereas the other tools did. As noted above, the developers of the Ecopod and Personal Barometer tools stated that they considered openness when they designed the tools, and this is reflected in the results where these tools promote openness to a greater degree than the other tools amongst postgraduate respondents.

These results indicate that generally school respondents were more critical of each other in terms of judging each others' fairness, compared with the postgraduate respondents. If the tools had an impact on the school respondents, it may have resulted in them becoming more opinionated following tool use and creating more of a debate. The reverse seemed to have happened with the postgraduates, who were likely to have had more of an idea as to the possible solutions to the scenario problem. The tools might have worked to converge their opinions regarding the scenario following use of the tool.

In the evaluation sessions involving the experts, openness was ranked eighth on the list of strategic objectives. Although only two developers considered openness during the design of their tools, openness was found to be promoted by all of the tools to varying degrees.

In the literature, openness was considered to be of importance in terms of environmental attitudes and behaviour, by authors such as Duncker (1963) and Grob (1995). During his investigations into environmental attitudes and behaviour, Grob created a model, which attempted to link environmental awareness, emotions, personal-philosophical values and perceived control and behaviour. Grob suggested that openness was an important element within the personal-philosophical component. Building on the work of Duncker (1962), Grob suggested the more open to new experiences an individual was, the more likely they would behave in an environmentally responsible way. Following his investigations, Grob found that open-mindedness was the single most important influence leading to individuals exhibiting pro environmental behaviour. The fact that openness or open mindedness is so important for contributing to pro environmental behaviour and that the ICT tools tested in this thesis appeared to promote openness bodes well for the future. Those developers that stated that they considered openness during the design actually developed the tools that promoted openness to the greatest degree. Therefore the both results from this investigation, and findings from literature suggest that in future, ICT tools should be designed in such a way as to promote openness, in order to aid individuals in becoming more environmentally responsible.

5.1.7 Bi-variate analysis

Statistical analysis was carried out on the results to determine whether either gender or response group (school and postgraduate) were correlated with the promotion of certain strategic objectives. Gender was investigated after research conducted by House (1999) and Mohai (1992) suggested that perceptions of local environment may vary as a function of gender. It was found by Mohai (1992) that females took a more protective view of the environment and by House (1999) that females were more critical of water quality. In this thesis investigation the results indicate that there was no significant relationship between gender and strategic objective promotion. There was also found to be no significance difference in strategic objective promotion between school and postgraduate respondents.

It was also hypothesised that there could be a difference in the promotion of strategic objectives following tool use due to the age of the respondents in the school and postgraduate groups. The younger respondents were considered more likely to be influenced by the tools simply because they were less likely to have reason to question the content, compared with the postgraduates who may have been more influenced by external factors. There could also have been a difference between those respondents that had a longer length or residency in the UK compared to others that had been living the UK for a shorter period of time. For example, those living in the UK for a longer duration could exhibit increased environmental knowledge specific to the UK.

However, there was no difference in the promotion of the strategic objectives following tool use, when both age groups and length of residency was tested using a Pearson Chi square test.

5.2 Comparative assessment of tool performance

When asked to determine which of the strategic objectives they considered when they designed the tools, there was a high variation in responses from tool developers. The individuals from the Environment Agency that were involved in the design of the Ecopod tool stated that they considered all of the strategic objectives that were listed in the questionnaire. These developers stated that the consideration of the entire strategic objective list was something that they 'strived' to achieve. Cranfield University, the developers of the Personal Barometer stated that they considered four of the strategic objectives, which were education (learning), inclusion, commitment (motivation) and openness. The Riverside Explorer and the Water Aid Game developers, both solely considered education (learning) at the design stage.

It is possible that those developers who indicated that they considered all of the listed strategic objectives mentioned, did so whilst designing their respective tools, although it may be the case that they considered the objectives to be desirable outcomes, or something considered after tool completion, say for example if the tool was to be evaluated following completion of the design process. Whatever the level of consideration given to the completion of the developer's questionnaire, this was tested

during the evaluation sessions involving both the school and postgraduate respondents and the experts.

During the literature review the key pieces of legislation relevant to environmental education was outlined. Specifically Agenda 21 considered the need to raise environmental awareness, with the hope that this would increase environmental responsibility in individuals. Involving individuals in environmental decision making and in the search for solutions made up another part of this strategy. Therefore the central outcomes of Agenda 21 were not only the identification of the need for environmental awareness and education, but also the identification of the benefits of citizen involvement and stakeholder engagement processes and public participation. This thesis considers environmental education and its importance in terms of providing access to individuals so that they are able to become informed, environmentally responsible citizens. Although this study concentrates on the importance of providing environmental knowledge, so that citizens can practise environmentally sound behaviours, the wider aspects of environmental responsibility, such as public participation in environmental decision making should also be considered.

Of the tools evaluated in this thesis, only the Water Aid Game explicitly presented the issues and benefits of public participation in its content. When asked which strategic objectives they considered when developing the tool, the designers stated that the sole objective they considered was education. If the Water Aid Game indeed promotes the benefits of public participation, the objective 'justice' may well have been considered. However, the developer may have only considered this strategic objective in terms of making direct references to them in the content of the game and therefore may not have considered them in terms of strategic objective promotion.

When comparing the results from the experts evaluation sessions, with the results from the school and postgraduate evaluations (where fewer strategic objectives were used), there are certain similarities. Education (substituted for learning) and the 'trust' elements scored highly in both exercises. However, this is where the similarities end. The results from the experts' evaluation reveal that commitment (exchanged with

motivation in the school and postgraduate evaluations) was the highest promoted objective.

These results have implications for the use of the four tools. Although the tools aided in promoting commitment / motivation, education, trust and inclusion, they promoted openness and justice to a lesser degree. These tools were suitable as providers of environmental knowledge, and environmental awareness raising, which is what the tools were primarily designed for, but did not create much of a sense of justice or openness according to the experts. These latter objectives are key to public participation and stakeholder engagement processes, so these tools are not likely to be beneficial in a stakeholder engagement context. In order for tools to be designed for such use, the developers of the tools would need to considered the desirable outcomes of an ICT tool designed to aid stakeholder engagement processes for example and then the ICT tool would require evaluation to ensure it achieves the outcomes. Few investigations have been carried out, but Sandrine Simon (2004) considered the way in which ICT tools that were designed to aid in social learning and environmental decision making could be evaluated using a systems learning approach. Following her investigations, Simon concluded that there were certain aspects that needed to be considered during the evaluation of ICT tools to promote social learning and participatory processes, such as to reflect on the context of the tool, who is going to use it and why, and why it is best to use ICT tools over other methods of delivery. As well as this, Simon considered the need for the consideration of interactions between individuals during the design of ICT tools.

Across all tools, the Riverside Explorer achieved the highest mean score of 2, (determined by using the scores greater than four given by each expert to calculate a mean). Both the Water Aid Game and the Personal Barometer scored 1.5 and Ecopod only scored 0.5. However, these results are still very low, out of a possible 10 on the Likert scale range, the highest scoring tool only scored a mean of 2. This shows that the experts considered that all of the tools were poor at promoting most of the objectives and suggests that changes need to be made in order for these tools to be useful in aiding environmental education. These scores were almost reflected in a secondary evaluation

activity where the experts were asked to make a direct comparison of the four ICT tools. The Riverside Explorer scored the most followed by the Personal Barometer and the Water Aid Game. Ecopod was the tool least favoured by the experts.

Of the individuals taking part in the expert evaluation, expert D gave the lowest marks for all of the tools, followed by expert C. Interestingly, these were the two experts from the industrial sector and this may have had a bearing on their opinions of the tools. Both thought that the tools were not designed with an appreciation of the user, but were developed in isolation meaning that the user had to adapt their learning style to it. For example, expert C did not favour Ecopod because it did not allow users much freedom in exploring the tool, or enable them to move backwards to visit a previous section. The time limit that it imposed on interaction was also felt to be unfavourable, the users exasperations at using Ecopod were heightened when parts of it crashed (which frequently occurred following the completion of the word search function). In this tool, users are required to complete various challenges (the crossword being an example) before going into the main part of the Ecopod to learn about water conservation. Although the challenges made the tool appear more like a game to the users, many of the older respondents, (both in the postgraduate group and some experts) got very frustrated, just wishing to move onto the main section.

Another comment was that the instructions that accompanied Ecopod were insufficient. At the beginning when the users are being introduced to the tool, the writing is very small and the black type on a dark background is hard to distinguish. As well as this, the screen changed very quickly, so many respondents didn't have time to read all the text. Finally many of the respondents did not realise that there was a time limit when playing the Ecopod tool, represented by a bar at the bottom of the gaming screen, so when this ran out and the respondents were told that they had destroyed their Ecopod, they were left feeling cheated, because they were not told that this indicator of their progress existed. Also the bar went down even if users do not make any mistakes and many respondents expressed their opinions on how unfair this was. One comment made by a respondent sums up these findings:

Respondent 1: Well, I consider myself to be quite computer savvy, I've worked in computers and finance.
Interviewer: Yes.
Respondent 1: But this thing (Ecopod)), I couldn't even complete the whole thing. I don't think it's a good package, I didn't realise the water bar, the bar at the bottom, was there until he's (a fellow respondent) telling me (during this scenario).
Interviewer: So it didn't explain that bit to you?
Respondent 1: No. Plus I couldn't, erm that flashing thing (Garden pre entry game) that was necessary to go into the bathroom section.

The quote above reflects the trouble that many respondents had when interacting with Ecopod concerning both the water limit bar and the challenges that they were required to complete to gain entry into the different sections of the Ecopod.

Compared to Ecopod, the other tools faired slightly better, the experts favouring tools that allowed them to visit each part of the application when they liked and at their own pace. Although having a time pressure in Ecopod made the tool more game-like, the experts found it to be detrimental to the overall experience of using the tool in terms of strategic objective promotion. The results from the experts evaluations indicate that the Riverside Explorer Personal Barometer promoted the strategic objectives to a higher degree compared to Ecopod and this could be explained by the increased level of interactivity.

The Water Aid Game involves users in decision-making regarding water issues in drought affected countries and individuals interacting with this tool are able to return to previous stages of the game if they wish, although this could affect their overall score. Many respondents from all groups commented on the way in which the screens were set out on the Water Aid Game. The main screen consists of a large animated picture which takes up most of the screen and a large amount of text that ran down the left hand column. Although many users liked the animated picture and a few found that you could click on certain pictures to answer the questions that were set, many stated that they would rather have a slightly smaller picture with a larger area for the text, so that they

would not have to scroll down or focus on one part of the screen for long periods. A small part of this discussion can be seen below:

Respondent 1: I think that if it's (the Water Aid Game) made for eleven to fourteen year olds, I don't know if it's too much to read in a small part of the screen? I mean it's not comfortable to go (scroll) down? Maybe if it appears in the whole screen?
Respondent 2: It's the most important part of the tool.
Interviewer: Yeah.
Respondent 1: and the pictures can be a bit smaller, in the under part.
Respondent 3: You don't know that you have to go down to move on, you get stuck and you don't know where you are going.

Expert A did not like the way in which the Water Aid Game seemed to stereotype drought issues, commenting specifically on the Red Cross car that is featured in the game and how this is always portrayed when issues effecting developing countries are reported in the media.

Like the Water Aid Game, the Personal Barometer allowed more interactivity when compared to the Ecopod tool. Many of the experts favoured this tool because it was based very much on the user. As well as giving users the option to explore the tool in whichever way they liked, the Personal Barometer also required the input of the users personal or household water consumption, therefore requiring knowledge from the user to help with the learning experience. Expert C commented on the beneficial nature of a user based tool. Many of the respondents remarked on how useful the information on conservation options was.

However, not all of the views of the respondents were positive with regards to the Personal Barometer, Expert A pointing out some errors in the text and the problems of assuming that everybody uses the same quantities of water when carrying out the same water use activity. The main problem echoed by many of the respondents from all groups, as well as the experts was the reporting at the end of the Personal Barometer.

An excerpt is taken from one of the school respondent groups as an example of when respondents commented on the use of language:

Respondent 1: Er, spelling mistakes, if it is going to English people then it should be spelt properly.
Respondent 2: I don't like the American word faucet; I think you should change that.
Interviewer: Oh yeah.
Respondent 1: Yeah, if its, if its going to go to mainly English people, then it should be in English. Not that other countries can't help out.
Interviewer: Yeah.
Respondent 1: But they (the developers) should make sure that it's spelt correctly.
Respondent 3: And you not use American words like faucet.

When users interact with the Personal Barometer, they have to estimate the number of times they carry out different water use activities in the home and they are provided with a calculation of their household water shadow at the end. Most respondents understood the concept of the water shadow, but found it difficult to determine the quantity of water they used compared with other individuals. In other words, as well as the water shadow, the respondents wanted to be told whether they used too much water. Expert C suggested that if water was being overused in one particular room in the house, this could be reported in the final stages of the tool, and could suggest possible conservation options in that specific room.

Finally, the results indicate that the Riverside Explorer was the top scoring tool amongst the experts. This application allowed users to explore the tool at their own pace and did not require any type of game playing on the part of the user. On average the experts favoured this tool and could appreciate its use either in the classroom or for use to aid homework. However, it is a tool that many of the users stated would be one that they would not return to. They remarked that it had its place as a learning aid, perhaps during a school lesson, or in a field study centre or park, but it was unlikely that they would return to it for another go, unless they needed to for homework. One of the

respondents recognised the need for ICT tools of this type and reflected on their own experiences.

Respondent 1: They (the wildlife centre) do talks every so often for kids and that, they used to do bat talks, because I quite like bats, so they used to like evenings where you could go and see and meet the animals, hold the animals and stuff and things like that and the country park near my house has got a wild life centre and its got displays and years ago it had stuffed animals and horrible things like that, but now it's the kind of place that they could use a tool like that and people could lean more.

From the experts evaluation it was found that many of the expert's comments were echoed by many of the respondents in the school and postgraduate groups. As stated previously, experts C and D gave the lowest scores to the tools in terms of strategic objective promotion and these were the respondents from industry. Their experience with tool use in industry may have influenced their opinions.

5.3 Aggregated results by platform and Strategic Objective

The discussion in Section 5.2 revealed which tools promoted which strategic objectives. In order to gain some insight into which objectives were promoted across the set of tools evaluated when school respondents were involved in the evaluation sessions, a ranking system was devised. As a reminder, Table 4.28 presents the outcome of this ranking.

Table 5.1 Ranking of strategic objective promotion across all tools when used by school respondents.

Ranking	Strategic Objective
1	Learning
2	TICT
3	TII
4	Openness
5	TID
6	Inclusion
7	Motivation

The information in Table 4.28 shows that the tools appear to have achieved their aims as far as learning is concerned, as all of the tools were designed to enable users to acquire knowledge, whether it was about river habitat diversity, water conservation in the home, or drought in third world countries. Two of the elements of trust were also instilled by the tools, with many school respondents trusting both the information existing within the computer tool and the institutions themselves. When the developers were asked if they considered trust, only the designers of Ecopod (Environment Agency) stated that they did so, although all elements of trust were promoted to a relatively high degree by all tools. As expected from the developers' results, justice and trust were promoted the least, these objectives only being explicitly considered during the development of the Ecopod tool. The results reveal that developers would need to perhaps focus their attention on justice and trust when designing tools to support and promote stakeholder engagement.

When the results of the postgraduate evaluation sessions were also ranked, it was revealed that the ranking table was very similar to that of the school respondents. Openness, TICT and TII were all well promoted, followed by trust in decisions made after use of the tools. Learning was ranked slightly lower in the postgraduate results compared with the school respondent results. Again motivation and inclusion were promoted the least (Table 4.29).

Table 5.2 Strategic objective ranking according to degree of promotion by ICT tools evaluated following use by postgraduates.

Ranking	Strategic Objective
1	Openness
2	TICT
3	TII
4	TID
5	Learning
6	Inclusion
7	Motivation

A direct comparison of strategic objective promotion following the evaluations involving the developers, users and experts is shown in Table 4.32. Similarities lie in the promotion of learning / education, but vary in terms of trust, which was not considered by many of the developers, but scored highly in the users' and experts' evaluations. The strategic objectives inclusion were considered by many of the developers but failed to be promoted to any great degree according to the evaluation of users and experts.

Few developers considered commitment / motivation and although this is reflected in the users results, the objective was judged to be promoted by the experts. Openness was promoted to a fair degree, according to the results of the users and experts evaluations, but where only the designers of Ecopod considered justice it was found to be promoted reasonably well as across all tools as judged by the experts.

From the literature it is clear that a wide range of all strategic objectives should be considered when designing tools for use in environmental education, although the results indicate that objectives such as motivation and inclusion would require further

consideration when future tools are designed for use by individuals to engender environmentally responsible behaviour.

In his work, Selwyn recognised the need to conduct future investigations that focussed on qualitative aspects, rather than quantitative aspects. In this thesis, the sociological side to ICT tool design was considered, and ICT tools were evaluated according to the six strategic objectives. Further investigations in this area would offer alternative perspectives, as outlined by Selwyn.

The findings of this investigation challenge Clarks (1994) claims that there are no benefits to be had in terms of learning from utilising different forms of multimedia. He stated that interacting with ICT tools would not improve upon existing learning techniques. Clark's claims are based on a lack of empirical evidence, even though a great number of investigations into learning and ICT tools have been carried out, the investigations have so far failed to reveal that learning is influenced by multimedia use. Whilst Clark states that continuing to investigate the impact that multimedia tools have on learning is a waste of time unless new theories regarding the design of multimedia tools, or the learning process are developed, other researchers remain optimistic.

In his debates with Clark, Robert Kozma (Clark, 1994) remained confident that with the careful consideration of cognitive processes, researchers will eventually find a critical link between multimedia attributes and learning. In his opposing views, Clark insisted that these multimedia attributes and learning should be treated as separate entities by educational researchers. Kozma's suggestions that a link between learning and ICT tool design must be found, have been developed in this thesis. Although many studies have been carried out which compare the use of multimedia tools with traditional teaching methods, this investigation has sought to determine a link with regards to the strategic objectives of tool use, rather than taking the more popular approach of studying the effectiveness of the human-computer interface. This investigation has highlighted the need to consider different aspects of ICT tool use, such as the strategic objectives and deployment context and if further research was carried out in this area, perhaps a number of links could be found between learning and the many ICT tool attributes.

The promotion of learning by all the tools evaluated is a clear finding from this investigation, and shows that when learning is compared to some of the other strategic objectives, it is promoted to a greater degree. As of yet, Clark has not considered other elements of ICT tool design and deployment. For example, he states that multimedia would never improve on traditional teaching methods, but has not considered the use of ICT tools as aids to teaching for example (in the form of additional help on top of the traditional teaching methods). The use of such tools in stakeholder engagement processes or for use by anyone with an interest in certain environmental issues are also not considered.

In their work, Parlangeli *et. al.*, (1999) identified the need to carefully consider the degree to which learning is affected by poor tool usability and examine the cognitive processes which yield such results. Parlangeli's study partly supports Clark's claims regarding multimedia and how its use does not improve on existing teaching methods if a tool is poorly designed. In their investigation Parlangeli and his fellow researchers carried out a study involving three groups of students. One group interacted with an ICT tool deemed to be poorly usable from a previous investigation, one group using the supporting material which came with the same ICT tool, but did not interact with the tool itself and finally, one group learnt (the same material) using traditional teaching methods. The results revealed the tool had a detrimental affect on learning in those students who interacted with it, this highlighting the importance of careful consideration of the design of future ICT tools for learning.

By comparing Clark's views with Kozma's, and by comparing these views with Parlangeli's findings, it becomes clear that further research specifically into strategic objective promotion by ICT tools is necessary. The debate between Clark and Kozma identified positive aims for the future in terms of ICT tool design, such as the need to find the link between strategic objectives.

Welp (2001) went someway toward these aims by identifying the different types of ICT available for various uses. In his investigations, Welp also conducted a study where he evaluated a participatory integrated assessment based computer tool and from the results

identified the need to provide individuals with support when using such tools, or to redesign and re-evaluate the tools so that individuals can usefully interact with them unaided. Welp concluded that two strategic objectives were necessary for consideration in his particular investigation, information (education) and transparency. In this thesis investigation, the developers were asked whether they considered education and all developers of the four tools considered education. Comparing these to the results from the evaluations involving the experts, although education was judged to be promoted to the greatest degree (compared with the other strategic objectives).

In this thesis, it is concluded that careful consideration of ICT tool design would ideally include not only the human-computer interface, but also strategic objectives and the deployment context. As of yet, it appears that these elements have been treated as separate entities and should be considered as an integrated system when future investigations are carried out on ICT tool design, usability and its influence on learning.

5.4 Reflections on the research method

There are a number of ways in which this investigation could have been improved upon. For example, only three respondent groups were involved in this investigation, the developers of the tested ICT tools, the user groups (both school and postgraduate respondents), and the experts. This only yielded a certain number of perspectives so therefore, a larger sample of respondents would have been desirable as well as a greater range of experts, including representations from public bodies, special interest groups and NGO's. Involving a greater number of respondents would potentially yield more robust results as well as legitimating the study by including a wider variety of perspectives. However, over a three year investigation, involving this number of individuals would have been difficult. Also in this thesis investigation, the evaluation sessions involving the user groups only involved four individuals per group, in order to assess the promotion of certain strategic objectives, such as openness and justice. It would have been more beneficial to attempt to run evaluation sessions involving a greater number of individuals in each group to see if this would influence results regarding the promotion of these strategic objectives.

When considering the way in which the strategic objectives were tested during the evaluation sessions involving the users, there were alternative ways in which the strategic objectives could have been measured and these were reflected on in Chapter 3 Section 3.5.1. For example, only three questions were asked during the pre and post interaction questionnaires. A greater number of questions could have been put to the users before and following tool use to test learning. However, three questions were found to be an ample number to test for the promotion of learning in this particular investigation.

In terms of trust, specifically trust in the institution that designed the tools, the user groups were asked whether they trusted the organisation that had developed the tool that they interacted with both before and following tool use. To explore this area further, a series of questions could be designed depending on whether the respondents had heard of the institution or not. If they had heard of the institution, it would have been beneficial to ask them more questions relating to their understanding of role of the institution in raising environmental awareness and if they hadn't heard of it, get them to try and state what they thought the organisation was responsible for and inform them of its actual role. Where trust in the computer tool was considered, the questions related to this strategic objective could be tied in with the trust in the institution strategic objective, whereby if respondents had not heard of an institution, their responses could be directly compared to their level of trust in the content of the computer tool designed by the same organisation. Finally, the respondents in this investigation were asked whether they trusted the decisions they had made in the scenario discussion. There was a chance that respondents were led by stronger members of the discussion group so therefore it would have been beneficial to ask respondents to make a decision regarding the scenario on their own, by writing down which decision they made and then having a group discussion. This could aid in the group discussing all ideas and reduce the chance that some respondents would be shy or feel awkward about sharing their ideas with the group. Also by aiding the discussion, the group would be more likely to end up gaining consensus amongst the group regarding the final decision.

In terms of testing the strategic objectives of motivation and inclusion, respondents were asked questions about generic environmental issues. In order to explore this area more, and to make it more relevant to the individual respondents, an alternative questioning approach could be adopted whereby respondents were required to give an example of an environmental problem which had affected them, or one that they had heard about on the news and then they would be required to explain what was done in reality to help remedy the problem (if indeed a solution was reached) and what the users think they would need to do to help solve the problem.

In many ways the strategic objective 'justice' was the most difficult objective to measure. Rather than looking for evidence of justice promotion in the interview transcripts, other methods could be adopted for example the use of content analysis could aid the investigation. Justice could be tested in the questionnaire sessions, by asking the respondents to state what their ideas of justice is in terms of environmental decision making. Finally, rather than solely testing openness using the indicator in the pre and post interaction questionnaires, openness could be tested in an alternative way. This could be by comparing the number of times respondents spoke during the scenario discussion and comparing the results both before and following tool use to see if openness was increased.

For this investigation, the evaluation methodology adopted was considered the best approach for determining strategic objectives promotion. Asking individual respondents questions or having 'one-on-one' sessions was impossible due to the need to include a group discussion to uncover the strategic objectives 'justice' and 'openness'. However, this approach caused problems in other areas, especially where the respondents from both user groups were required to fill in the pre and post interaction questionnaires. School students with a wide range of abilities took part in the evaluation sessions, and some students who completed the questionnaires very quickly had to sit and wait for the other respondents to finish. This not only led to those respondents who had finished becoming frustrated and causing a distraction to respondents who took more time to complete their questionnaires, but it also put those who were still answering their questionnaires under more pressure to complete them. However, rather than the

individual respondents reading through the questionnaires themselves, the interviewer could read through each question, one at a time, allowing a short period between one question and the next for the respondents to answer the questions. This method could have been useful, especially where the school respondents were concerned.

The issues considered during the scenario discussion differed according to the tool that each of the user groups interacted with. It would have been useful if the same scenario was discussed by all user groups who took part in this investigation, but to do this the ICT tools selected would have had to be based around the same water issue. Also it was problematical to ensure that the level of difficulty of the issues presented in the scenarios were comparable. By using the same scenario for all discussions would combat this problem.

Although, upon reflection, there were a number of ways in which the investigation could be carried out, the use of pre and post interaction questionnaires and the discussion scenarios were considered the best methods to provide a starting point for the evaluation of ICT tools in terms of desirable strategic objectives.

5.5 Summary

This chapter has discussed the results from the various evaluation activities and it was found that the tools investigated exhibited a variable performance, but overall were reasonable at promoting the strategic objectives listed. Although objectives such as learning, education, trust and openness were promoted to a greater degree compared with the other objectives, careful consideration of the design of future ICT tools for environmental education is warranted. Frequently, the results showed that the ICT tools evaluated failed to promote inclusion and motivation, two objectives which are vital to the success of engendering environmentally responsible behaviours. It is necessary to determine an evaluation methodology to aid the design of ICT tools for environmental education and for the encouragement of individuals to become environmentally aware, because even when the developers claimed that they considered certain strategic

objectives, it was found during the expert, school and postgraduate evaluations that many were not promoted by the four tools.

There are a number of ways in which this investigation could have been improved upon. For example a larger sample of respondents would be beneficial as well as a larger range of experts, including members of the general public, public bodies, interest groups and NGO's. Monetary constraints prevented the involvement of these groups. Also safety was a concern, it would have been difficult to advertise and screen members of the public and if an issue arose, this could have put the evaluation sessions in jeopardy.

6 Conclusions and future work

6.1 Review of study context

This thesis work investigated the degree to which ICT tools designed to support environmental awareness, promoted a number of strategic objectives. From the work of scholars such as Naess (Higgins, 1998), and later by Huesemann (2001) and others it has become clear that humankind needs to start taking a proactive role with regards to the environment, rather than continuing to rely on scientists, and technology to solve environmental problems. In order to engender environmental responsibility in individuals, environmental awareness raising must take place and individuals need to have the information to become environmentally responsible in the first place.

Various pieces of legislation have aided this process, first through Agenda 21 relating to the need for sustainable development in 1992, and then the Aarhus convention in 1998. The most recent piece of legislation pertinent to environmental awareness is the United Nations 'Decade for sustainable Development', and from this Education for Sustainable Development (DfES, 2005) was formulated. Spanning the national curriculum, this is not a subject but a way in which a school's environment can be managed, whilst focussing on education. There are initiatives which aid schools in satisfying their ESD needs, and one such scheme is Eco-Schools (Eco-Schools, 2005).

However, another way in which environmental information can be presented is in the form of an ICT tool. Authors such as Haklay (1999), Wild and Quinn (1998) and Guimãres Pereira *et. al.*, (2003) have reported the benefits of the use of ICT tools for environmental education and a number of tools exist, such as the environment agencies K-World (2002). To determine whether ICT tools achieve their learning objectives, investigations can be carried out, and more often than not, these focus on the Human Computer Interface (HCI) (Hinostroza and Mellar, 2001; Crumpton and Harden, 1997; Clark, 1994). However, in this thesis, two further elements that could potentially be investigated, the deployment context and the strategic objectives were considered. A

scoping study revealed that the strategic objectives were the most feasible for examination in this thesis investigation, and four ICT tools were evaluated by three different respondent groups. The way in which this research was conducted and the responses to the research objectives is explored in Section 6.2.

6.2 Knowledge contribution – Responding to the research objectives

The central aim of the research reported above was to determine the extent to which ICT tools designed to support environmental awareness promote a number of strategic objectives. To accomplish this aim, the investigation was guided by a set of objectives first introduced in Chapter 2. The following sections re-state these objectives and identify how the thesis has responded to them.

6.2.1 To identify the main strategic objectives of relevance in the context of ICT tool designed to aid environmental education.

The strategic objectives investigated in this study were selected followed a targeted literature review (Chapter 2, Table 2.8).

The strategic objectives identified as the main objectives of relevance in the context of ICT tool designed to aid environmental awareness were the promotion of:

1. Trust
2. Education / Learning
3. Justice
4. Inclusion
5. Commitment / Motivation
6. Openness

6.2.2 *To design an appropriate research methodology to determine strategic objective promotion by ICT tools. This would be in the form of an evaluation activity.*

This objective was achieved by first identifying the main strategic objectives to be tested and by selecting the ICT tools to be included in the investigation and the respondent groups that would take part in the evaluation sessions. The ICT tools selected for inclusion in this investigation were the Riverside Explorer, Ecopod, The Personal Barometer and the Water Aid Game. Three respondent groups were selected; the developers of the ICT tools, potential users (which in this investigation were school and postgraduate students), and experts in either the design or evaluation of ICT tools, or the environment. The developers of the tools were requested to complete a short questionnaire. They were asked whether they considered each strategic objective during the design of their respective tool and to indicate this with either a tick for yes, or a cross for no. This was conducted via e-mail, so little organisation was required for this evaluation activity.

In the evaluation sessions involving the user groups (the school and postgraduate respondents) a questionnaire was used to measure the strategic objectives. For the identification of the promotion of some strategic objectives a scenario problem was set, with the aim of inciting a discussion of the issue between respondents following which a decision was made. The evaluation process itself was as follows:

1. The administering of a pre interaction self complete questionnaire.
2. Discussion of a platform specific pre interaction scenario (to be taped).
3. Interaction with the ICT tool
4. The administering of a post interaction self complete questionnaire (Same wording as pre interaction questionnaire).
5. Discussion of a platform specific post interaction scenario (to be taped. Same scenario as number 2).

A two stage questionnaire was used by the experts during the evaluation sessions. During these one-on-one sessions the experts were required to interact with each of the tools and then judge the degree to which they considered each strategic objective to be promoted. Following this the experts were asked to directly compare the tools.

Data analysis techniques and metrics were identified; the data collected during the evaluation sessions were collated and stored in a database. The types of responses that were expected from the questionnaires, (i.e. whether the answers were 'yes' or 'no', or 'correct' or 'incorrect') were also determined. Following this, the way in which each strategic objective would be analysed and the criteria applied to test strategic objective promotion in each case was set out in Table 3.8.

Some of the problems and difficulties encountered when organising the evaluation sessions were discussed, particularly when contacting local schools and ensuring that the correct number of postgraduate respondents attended each evaluation session. The benefits of transcribing the evaluation session very quickly following the scenario discussions were soon apparent after a couple of evaluation sessions were carried out. Although a number of potential problems were identified in this section, the majority were either identified during the scoping study investigation or were overcome during the process of conducting the evaluation sessions. Further reflections on the research method adopted during this study can be found in Section 5.4.

6.2.3 *To test four ICT tools to determine the degree to which they promote the strategic objectives identified in 1 (above).*

The developers were asked to complete a questionnaire to determine which of the strategic objectives they considered when they designed their tools and the developer of the Ecopod application (The Environment Agency) stated that they considered all of the strategic objectives listed (trust, education (learning), justice, inclusion, commitment (motivation) and openness). Cranfield University, the developers of the Personal Barometer, considered 4 of the strategic objectives (education (learning), inclusion, commitment (motivation) and openness). The designer of the Riverside Explorer (the

Environment Agency) stated that they considered only one strategic objective, whilst during the development of the Water Aid Game, only one strategic objective was considered. All developers considered education as a priority objective.

In the evaluation sessions that involved the school students, and looking at the normalised results, learning was found to be promoted in the majority of respondents that could improve across all four tools, followed by trust in the content of the tool (TICT). The other two elements of trust, Trust in the institution (TII) and trust in decisions made following tool use (TID) were also promoted in a large number of school respondents, as well as openness and inclusion. The strategic objective promoted in the least number of school respondents was motivation. The results for the postgraduate results revealed a different picture. The order of strategic objective promotion following the postgraduate evaluation sessions was as follows: Openness, TICT, TII and TID. Learning and Inclusion was promoted slightly less, and Motivation promoted the least. These results revealed certain similarities between groups.

The results from the school student evaluations on the promotion of justice revealed that Ecopod promoted this objective to the greatest degree, followed by the Water Aid Game, the Riverside Explorer and the Personal Barometer. For the Postgraduates the Riverside Explorer was found to promote justice to the highest degree, followed by the Water Aid Game, Ecopod and the Personal Barometer.

The strategic objectives were ranked across all tools in the expert's evaluation and it was found that commitment (motivation), education (learning) and trust were the highest scoring strategic objectives, with objectives such as inclusion and openness occupying the mid-table. The lowest scoring objectives was justice.

During the experts' evaluations, none of the strategic objectives were promoted to any reasonable degree, although the Riverside Explorer promoted the most strategic objectives, followed by the Personal Barometer and the Water Aid Game. The Ecopod tool was the lowest scoring tool. The experts that were from industry gave the lowest scores.

The results of this investigation indicate that although tool performance was variable, overall, they poorly promoted the strategic objectives listed. Some of the strategic objectives were promoted to a greater degree compared to others; those more highly promoted were learning, education, trust and openness. Frequently, the results showed that the ICT tools evaluated failed to promote motivation, one objective that is vital to environmental responsibility.

6.2.4 *To draw conclusions regarding an evaluation methodology which could potentially be used to evaluate all future environmental education ICT tools.*

This work has enabled conclusions to be drawn regarding an evaluation methodology which could potentially be used to evaluate environmental ICT tools. The results revealed that the strategic objectives were not being promoted to any large degree. Certain objectives were promoted more than others, but objectives such as motivation were promoted little by the tools. The problems and limitations of the adopted research method are provided in Section 5.4. The text below reports reflections on an improved method that could be adopted for future studies.

By reviewing the results and reconsidering the evaluation methodology adopted in this thesis, a three stage evaluation methodology is proposed, which would be conducted during the ICT design process. The first stage would be to carry out an investigation to identify specific desired strategic objectives relevant to environmental awareness. The second stage would be to use a similar evaluation methodology to the one presented in this thesis, to evaluate tools designed to support environmental education and awareness raising. The strategic objectives which were found to be difficult to measure, for example justice, may be better evaluated through a more in-depth scenario discussion session compared to the one adopted in this thesis. Repeated use of the ICT tools by the users could also help to promote certain strategic objectives, such as motivation. Finally, this evaluation methodology would be part of an ongoing process, once the tools have been evaluated and the results analysed the changes can be made to ensure that the tool promotes the strategic objectives listed.

6.2.5 *To suggest changes which could to be made to pre existing tools in order to improve their effectiveness as tools for environmental education.*

This investigation also allows us to make some suggestions on the improvement of existing tools and the design of future tools for environmental education and awareness raising. From the comments received during the expert evaluations, future ICT tools should be based around the user, that is, the tool should directly relate to the user in some way. A couple of the expert evaluators felt that the Personal Barometer achieved this to some degree, as this tool requires users to draw on experiences from their own lifestyles to enable interaction with the tool. This concept of user-centeredness is important, if users are required to input information about their own lifestyles then they are more likely to be able to relate to the tool itself, and this would hopefully lead to the promotion of more strategic objectives. Finally, the tools themselves could take the concept of environmental responsibility further by outlining the issues of public participation. The Water Aid Game does this to some extent when it addresses the importance of involving members of the public in decision making.

It may be the case that to promote certain strategic objectives, the deployment context should also be considered. For example, respondents interacting with a tool may need to visit the tool a number of times for objectives such as inclusion or motivation to be promoted. Also, the place that the tool is used may have a bearing, for example, school children may be or may not be motivated to a higher degree with regards to helping with an environmental issue in their local area if they interacted with an ICT tool during an educational trip to a field study centre for example, than compared with use of the same ICT tool in the classroom or at home. There must also be a need for citizens to interact with the ICT tools. School children may have to interact with ICT tools because it is required of them to complete their homework, or adults may need to use a tool because they wish to learn about issues that are affecting their local areas. However, where individuals are not directly affected by an issue, but their views or aid is required, it is important to carefully consider the design of tools which could work to spark an interest.

6.3 Suggestions for future work

Future work could potentially focus on a number of elements with regards to ICT tool design. This work has concentrated on the need to consider certain strategic objectives during ICT tool design, but there is also a need to carry out targeted investigations into the individual strategic objectives mentioned. A definitive list of desirable strategic objectives to aid environmental awareness could also be devised.

The evaluation methodology developed in this thesis investigation must be further tested to identify and eliminate any bias within both the procedure itself and the sampling method. If this evaluation methodology was to be applied on a wider scale, then work must be first carried out which would test this method. As evaluation methods traditionally have focussed on elements of the human computer interface, for example to test usability, and limited work has been carried out on evaluation methods to test for strategic objectives promotion, there is a need for further investigation.

The use of ICT tools to aid in environmental awareness, and the evaluation of such tools can be seen as being interlinked. So for example, the three elements identified as being of importance in this thesis are the strategic objectives, human computer interface and the deployment context. As presented in this thesis, much work has been carried out to evaluate the impact of the human computer interface in terms on learning or usability for example, but limited work has been conducted which focuses upon the evaluation of tools in terms of strategic objectives promotion or deployment context. It is also necessary to determine how these elements are linked and where the knowledge gaps lie in relation to ICT tool design.

In this thesis it was found that there was no significant difference in strategic objective promotion between males and females nor was there a difference between school and postgraduate respondent groups. Neither respondent age, nor length of residency in the UK had an impact either. Investigation is warranted into this area, as it is possible that

during the evaluation sessions the ICT tools created a level playing field with regards to strategic objectives promotion.

The respondents' past experiences of tool use were not taken into account in this investigation. If work of this kind were to be conducted in the future, it would be beneficial to take into account these experiences; for example, whether the respondents had a lot of experience with using ICT tools, whether they possessed a certain amount of specialist knowledge in the issues covered by the ICT tools, or whether they had taken part in decision making regarding the environment before. All of these factors could have an impact on the results in terms of strategic objectives promotion.

Finally, following this investigation, a case can be made for the revision of the strategic objectives themselves. Specifically, the ambition of the strategic objectives may need to be reconsidered.

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I Appendix – Developers Questionnaire

Strategic outcomes	**Is your platform designed to promote the following function (Y / N)?**
Trust	
Education	
Consensus	
Justice	
Inclusion	
Knowledge pooling	
Transparency	
Communication	
Democracy	
Quality of decisions	
Credibility	
Commitment	
Openness	

II Appendix - Users Questionnaire

Respondent.....

Name.....

Age.....

Gender.....

How long have you lived in this country.....

1. Can you tell me three things that a freshwater Otter might eat? (Three answers).

Answer 1.....

2.....

3.....

2. Please explain in your own words what a Dam is?

Answer.....

3. What is the maximum age a trout can live up to?

Answer.....

The tool you are about to evaluate was developed by the Environment Agency.

4. Are you familiar with this organisation?

Please tick

Yes ☐

No ☐

5. If yes, what does it do?

Answer.....

.....

'The Environment Agency is responsible for controlling pollution to land, air and water in England and Wales. They also control abstraction of water from rivers, lakes and groundwater supplies, provide flood and sea defences to protect people and manage freshwater fisheries. In carrying out these activities their goal is to help improve the environment to help make it a better place for wildlife and for people to enjoy'.

- Are you clear on the role of the Environment Agency?

- If no, please ask the interviewer for an explanation.

6. What level of confidence would you have in the decisions made about environmental issues on your behalf by this organisation?

Please select an answer using the **confidence scale** (circle a number).

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion

7. What level of confidence would you have in the information presented in an ICT tool designed by the Environment Agency?

Please select an answer using the **confidence scale** (circle a number).

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion

8. Would you get involved with helping solve a water environment issue affecting your local area?

Please tick

Yes ☐

No ☐

9. If yes, why?

Answer.....

10. If not, why not?

Answer.....

11. If yes, how many weekends a year would you be prepared to volunteer your time for?

Number of weekends ☐

12. Do you try and save water in your house?

Please tick

Yes ☐

No ☐

13. If yes, can you tell me how?

Answer.....

14. Do you think that wildlife habitat destruction is a problem that you should be concerned with?

Please tick

Yes ☐

No ☐

15. If yes, why?

Answer.....

16. If not, why not?

Answer.....

Scenario

Imagine that you live near to a wilderness area which has been untouched for a long period. A river runs through a section of the area and is surrounded by different species of plant. Both animals and plants live in and around the water. No one walks through the wilderness because the area is overgrown and there is no visible pathway. Some local residents become displeased with the unsightly area and suggest that it is made into a park, by clearing some of the plants away and putting a path made of wood chippings along a specified route. Local environmentalists think that this would be a bad idea because the removal of the plants would lead to a loss of wildlife in the area.

Imagine you are in charge of making this decision. Would you:

a) Keep the area the way it is, making no changes whatsoever?

This is beneficial because it will preserve wildlife habitats, but people will still be displeased with the area.

b) Make the changes and consider the consequences.

This could be beneficial because by building a pathway, people would be encouraged to visit the area and be able to look at and possibly learn about the wildlife. People could be asked to make a small donation which would help to conserve the area. The local people are pleased with the outcome.

Please discuss what you would do within your group and vote for an option.

17. How confident are you that you made the right decision? Please indicate on the **confidence scale** (circle a number).

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion

18. How fair do you think the other members of your group have been in discussing the problem and reaching a decision? Please look at the fairness scale and write down the answer in the table below.

Write the names of each member of the group and rate how fair you thought they were by selecting a number and ticking the appropriate box.

Respondent name	**Not fair**						**Very fair**	**I have no opinion**
(Do not write your own name)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	

Interaction

Riverside explorer activity – Intermediate survey

'Select practice your river survey and then **intermediate** river survey. Then select Mountain River 6138 and begin answering the questions regarding the river environment. To answer the questions please select answers from the list provided. Some questions require more than one answer. If you require any information or definitions of any of the terms used, please select the word contained within the file on the bottom of the page. Both a written and pictorial explanation of the word will be available. Please clearly write the question number and answer below'.

Please write down your answer before clicking on the surveyors answer!

1a) What is the left bank made of?

Answer .....

1b) What is the right bank made of?

Answer.....

2a) What is the shape of the left bank?

Answer.....

2b) What is the shape of the right bank?

Answer.....

3) What is at the bottom of the river?

Answer.....

4) What is the water movement like?

Answer.....

5) Are there any plants in the water?

Answer.....

6a) What types of plants are growing along the left bank?

Answer.....

6b) What types of plants are growing along the right bank?

Answer.....

7a) How many trees are growing along the left bank?

Answer.....

7b) How many trees are growing along the right bank?

Answer.....

8) What are the features along the river?

Answer.....

9) What artificial features are there?

Answer.....

10) What is the nearby land used for?

Answer.....

11) Are there any signs of recent management?

Answer.....

Please make sure you also look at:

- The information about Otters (**Select river wildlife habitats section** and then **about river wildlife**).
- The information about Dams (**Select how rivers shape the land** and then **find out about the river basin**).
- The information about Trout (**Select river wildlife habitats section** and then **about river wildlife**).

19. Before you interacted with the tool I asked you if you could tell me three things that a freshwater Otter might eat. Now that you have used the tool can you tell me the answer?

Answer 1.....

2.....

3.....

20. Before you interacted with the platform I asked you if you could explain in your own words what a Dam is. Now that you have used the tool can you tell me the answer?

Answer.....

21. Before you interacted with the platform I asked you what the maximum age a trout can live up to is. Now that you have used the tool can you tell me the answer?

Answer.....

The tool you have just used was developed by the Environment Agency.

22. What level of confidence would you have in the decisions made on your behalf by this organisation?

Please select an answer using the confidence scale (circle a number).

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion

23. What level of confidence would you have in the information presented in an ICT tool designed by the Environment Agency?

Please select an answer using the confidence scale (circle a number).

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion

24. Would you like to get involved with helping solve a water environment issue affecting your local area?

Please tick

Yes ☐

No ☐

25. If yes, why?

Answer.....

26. If not, why?

Answer.....

27. How many weekends a year would you be prepared to volunteer your time for?

Number of weekends ☐

28. Now that you have used the tool, will you try to save more water in your home?

Please tick

Yes ☐

No ☐

29. Now that you have used the tool do you think that wild life habitat destruction is a problem that you should be concerned with?

Please tick

Yes ☐

No ☐

30. If yes, why?

Answer.....

31. If not, why not?

Answer.....

32. If a member of the public used this tool to learn about an environmental issue and then volunteered to help solve an environmental problem that affects your local area, what level of confidence would you have in the decisions they made after using this tool? (circle a number)

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion formed

Scenario

Imagine that you live near to a wilderness area which has been untouched for a long period. A river runs through a section of the area and is surrounded by different species of plant. Both animals and plants live in and around the water. No one walks through the wilderness because the area is overgrown and there is no visible pathway. Some local residents become displeased with the unsightly area and suggest that it is made into a park, by clearing some of the plants away and putting a path made of wood chippings along a specified route. Local environmentalists think that this would be a bad idea because the removal of the plants would lead to a loss of wildlife in the area.

Imagine you are in charge of making this decision. Would you:

a) Keep the area the way it is, making no changes whatsoever.

This is beneficial because it will preserve the wildlife habitats, but people will still be displeased with the area.

b) Make the changes and consider the consequences.

This could be beneficial because by building a pathway, people would be encouraged to visit the area and be able to look at and possibly learn about the wildlife. People could be asked to make a small donation which would help to conserve the area. The local people are pleased with the outcome.

Please discuss what you would do within your group and vote for an option.

33. How much do you trust the final decision you made as a group? Please indicate on the confidence scale. (circle a number)

No confidence						**Very confident**
1	**2**	**3**	**4**	**5**	**6**	**7**

8 = No opinion formed

34. How fair do you think the other members of your group have been in discussing the problem and reaching a decision? Please look at the fairness scale and write down the answer in the table below.

Respondent name	**Not fair**						**Very fair**	**I have no opinion**
(Do not write your own name)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	

III Appendix - Experts Questionnaire

Part 1

Please complete the following tables by judging the degree to which the I.T. platforms you are about to use promote the strategic objectives listed.

First, read through the strategic objectives and then judge the degree to which they are achieved by the tool. Make sure that you thoroughly familiarise yourself with the tool and then either during or following tool interaction complete the table.

Part 2

After you have used all of the tools you will be asked to compare them by giving them an overall score. This score will determine which tools you consider, on balance, to achieve the best positive balance in promoting the strategic objectives.

Please remember that you have been asked to participate in this evaluation because of your expertise in the field of stakeholder engagement, ICT tool design or education. We are interested in your opinion as a professional, not as an individual

Descriptions of the strategic objectives

(To what degree does each tool promote the strategic objectives below?)

Trust

Increased access to data and information on natural resource management issues can increase trust in three specific respects;

- Trust in the institution that developed the ICT tool.
- Trust in the information presented in the tool.
- Trust in the decisions made by the individuals after using the tool.

Education

ICT tools can be used to empower the individual through enhancing their knowledge and understanding. Becoming familiar with new concepts and processes and understanding the relationships between phenomena are important elements to such knowledge enhancement.

Consensus

ICT tools can serve to promote a convergence of opinion regarding an environmental issue in the sense that they are better able to discuss the issues and ultimately come to a conclusion to which all or most participants agree.

Justice

ICT tools can promote a sense of justice among users. In particular, by allowing users to explore the relationships between processes or phenomena and by creating a common claim the credibility of information, decision or decision processes may be deemed fairer.

Inclusion

Broadening the constituency of consultation via the use of ICT tools and clear demonstrations of issues in a way which links personal behaviour, attitudes, and utility to choices creates wider ownership of an issue.

Knowledge Pooling

Many ICT platforms facilitate the sharing and exchange of knowledge. Such collaborative working or studying supports elicitation of both expert and local knowledge.

Transparency

Honest and sincere representations within ICT tools can promote a sense of transparency – a feeling that there are no disingenuous or artificial claims being made.

Communication

ICT tools can encourage communication and interaction between users (perhaps following tool use) as tool use raises new questions and prompts action.

Democracy

ICT use and wider participation generally meets the ambitions of governance principles based on extending democracy.

Quality of decisions

ICT tools can improve the quality of decision making through promotion of several associated strategic objectives (e.g. consensus, communication and knowledge pooling).

Credibility

Credibility can be promoted through use of ICT tools by an awareness by users of the quality and legitimacy of the information presented.

Commitment / Motivation

ICT tools can empower users and motivate them to take a closer interest in an issue or even take action.

Openness

ICT tools promote openness by being publically accessible sources of knowledge and by presenting information in a commonly recognizable format. As such, the tools act as a common reference point for debate and dialogue.

Part 1

Tool: Riverside Explorer
Description: This tool allows the user to investigate river systems in England and Wales, focussing on river sites, physical processes and the flora and fauna existing in each habitat.

Please select an answer by ticking the appropriate box.

Strategic outcomes	Does not promote the strategic objective						Promotes the strategic objective	No Opinion
	1	2	3	4	5	6	7	8
Trust								
Education								
Consensus								
Justice								
Inclusion								
Knowledge pooling								
Transparency								
Communication								
Democracy								
Quality of decisions								
Credibility								
Commitment / Motivation								
Openness								

Tool: Ecopod

Description: An environmental 'game' based in the year 2020. Years of water misuse have taken a terrible toll on the environment, resulting in the near depletion of our most precious resource and forcing humans to dwell in Ecopods. The user saves water by successfully completing different challenges in different sections of the Ecopod.

Please select an answer by ticking the appropriate box.

Strategic outcomes	**Does not promote the strategic objective**						**Promotes the strategic objective**	**No Opinion**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Trust								
Education								
Consensus								
Justice								
Inclusion								
Knowledge pooling								
Transparency								
Communication								
Democracy								
Quality of decisions								
Credibility								
Commitment / Motivation								
Openness								

Tool: Personal Barometer

The Personal Barometer is designed to encourage the user to conserve water within the home by visiting rooms in a virtual house. The user inputs their household's weekly consumption which is presented in terms of a water shadow. Water saving information is also available.

Please select an answer by ticking the appropriate box.

Strategic outcomes	**Does not promote the strategic objective**						**Promotes the strategic objective**	**No Opinion**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Trust								
Education								
Consensus								
Justice								
Inclusion								
Knowledge pooling								
Transparency								
Communication								
Democracy								
Quality of decisions								
Credibility								
Commitment / Motivation								
Openness								

Tool: Water Aid Game

The Water Aid Game demonstrates to the user the problems of drought in Ghana, Nepal and Ethiopia. The user has to make decisions as to the best way to acquire a water supply by working with the villagers.

Please select an answer by ticking the appropriate box.

Strategic outcomes	**Does not promote the strategic objective**						**Promotes the strategic objective**	**No Opinion**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Trust								
Education								
Consensus								
Justice								
Inclusion								
Knowledge pooling								
Transparency								
Communication								
Democracy								
Quality of decisions								
Credibility								
Commitment / Motivation								
Openness								

Part 2

Now that you have used the tools, please provide an overall rating for each one.

Tool	Poor									Excellent
	1	2	3	4	5	6	7	8	9	10
Riverside Explorer										
Ecopod										
Personal Barometer										
Water Aid Game										

Definition

Excellent

This tool achieves all of the strategic objectives to the highest degree. There is a large amount of evidence which points to the ability of the tool to promote the strategic objectives.

Poor

This tool fails to promote any of the strategic objectives. There is no evidence of the promotion of any of the strategic objectives in this tool.